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Trogonophis wiegmanni Kaup, 1830 - Tunisia, El Kef

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***Trogonophis wiegmanni* Kaup, 1830 (Squamata Trogonophidae)**. The checkerboard worm *Trogonophis wiegmanni* (so called for its distinctive checkered pattern of dark and light scales) is a legless, fossorial lizard belonging to the order Amphisbaenia Gray, 1844, an ancient group of reptiles that includes few living representatives in the Palaearctic. Distributed from southwestern Morocco to northwestern Tunisia (including the coastal islands Chafarinas and Habibas), it is a Maghrebian endemic and also the only North African representative of the family Trogonophidae Gray, 1865. Within this geographic range, the species occurs from the sea level up to 1,900 m a.s.l. in a wide variety of habitats of the Mediterranean biota, such as bare sandy patches, steppe, oak forests, juniper shrubs, pastures, and cultivated areas. It is a viviparous lizard characterized by strong sexual dimorphism, with males having longer tails and larger heads than females. However, many aspects of its social behavior, biology, and ecology remain still poorly known. The genus has been considered for a long time monotypic, but recent molecular investigations carried out by Salvi et al. (in Mol. Phyl. Evol., 120: 118-128) have found the occurrence of three cryptic lineages (two from Morocco, one from Tunisia and Algeria), although not yet described as distinct species. The populations from central and western Morocco were previously referred to the subspecies *T. w. elegans* (Gervais, 1835). The specimen depicted in the photo was found in El Kef, near Kaser el Moulouk (Tunisia), therefore, it should belong to the nominal subspecies.

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Physiological and Biochemical behaviour of *Atriplex canescens* (Pursh) Nutt. (Caryophyllales Chenopodiaceae) under salinity stress

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ABSTRACT The halophytic species *Atriplex canescens* (Pursh) Nutt. (Caryophyllales Chenopodiaceae) was submitted to increasing levels of salinity stress (NaCl) in order to understand and quantify as well some physiological and biochemical responses. The results that have been obtained showed that plant biomass production was a function of salinity gradient. As far as chlorophyll content was concerned, decreasing content was observed for chlorophyll (a) and chlorophyll (b). The energetic potential elaborated by the species was inversely proportional to salt concentration. The accumulation of osmotic substances such as proline, soluble sugars and total proteins content increased as salinity level was increasing. These results show how important is to verify specific adaptative mechanisms to salt stress. In fact, in the present study, it is worth to emphasize how osmoregulation constitutes a reliable and interesting strategy for the species to withstand salt stress. Such an analysis may also be used in plant selection at early stage as predictive indirect tests to evaluate the possible integration of plant breeing programs.

KEY WORDS Adaptation; *Atriplex canescens*; halophyte; osmoregulation; physiology; salinity.

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INTRODUCTION

Salinisation is defined as an enrichment of the upper surface of the soil by soluble salts. Salinisation of the soils and water is one of the major abiotic factors that limit plant productivity and agronomic yield (Zid & Grignon, 1991). In arid and semi-arid ecosystems, it results from high evaporations of water from the soil (Munns et al., 2005) and from irregular rainfall (Mezni et al., 2002). According to Ben Naceur et al. (2001), unfair irrigation is the cause of salinity. In Algeria, almost 3.2 millions hectares are threatened by salinity (Belkhodja & Bidai, 2004). Plants respond to environmental constraints by numerous changes and reveal the multifactorial character of tolerance and adaptative mechanisms of abiotic stress. The response to salt by plant species depends on the species itself, the variety, salt concentration and developing stage of plant (Ben Naceur et al., 2001). Under severe stress, plants react by several mechanisms ; physiological and biochemical ones are those which are often implicated in enzymatic activity (Stephanopoulus, 1999). Synthesis of organic compounds actig as osmoprotectors or osmotic regulators is among the very well known strategy (Ratinasabapathi et al., 2000). Meas & Nieman (1975) and Shannon (1984) have identified criteria of salt tolerance, as far as

grain yield, seed vigor, foliaire damage and height of plants were concerned.

Many other approaches, such as anatomic, ecological, physiological and molecular ones, were used in order to understand to what extend these modifications may reduce harmfull effects of salt stress (Poljakoff-Mayber, 1988). As we consider salt tolerance mechanisms, according to Piri et al. (1994) resistance of plants is expressed by the capacity to survive and reproduce in presence of salt stress conditions. In plants that are sensitive to NaCl, Na+ cation is accumulated in the leaves. This kind of types are called "excluders", as compared to tolerant ones to NaCl that are called "includers". in this last types, leaves are less Na+ concentrate than roots (Haouala et al., 2007). According to Hadjadj (2009), soluble sugars accumulation in leaves is important under salt stress. In numerous species more or less resistant, it was observed an increase of total sugars (Asloum, 1990), resulting of non occuring glycolysis. Osmoregulation is one of the main adaptative strategies in response to abiotic stress, particulary salinity and drought (Benhassaine et al., 2010). Rezkallah et al. (2014) showed that accumulation of NaCl had an effect on physico-chemical characteristics of the soil. Al Satari (2014) demonstrated that an efficient use of arid soils may occurr by growing several species in the same area thus having a better valorisation of these soils. On the other hand, the choice of the species to be grown in arid and semi-arid zones is determined, according to Falasca et al. (2014) by several factors, among which temperature, rainfall, type of the soil and water availability for irrigation. In salt soils, some species are threatened by extinction (Chamard, 1993); others show adaptative mechanisms (Hare & Cress, 1997). In fact, in these environments, plants adjust osmotically (Godghirs et al., 1990) their cell content by synthetizing amino acids, such as prolin (Ashraf & Mc Neily, 2004).

MATERIAL AND METHODS

Plant material

Seedling plants of *Atriplex canescens* (Pursh) Nutt. (Caryophyllales Chenopodiaceae) issued from the nursery of H.D.S.D. (High District of Steppic Development) were grown in pots under semi-controlled conditions.

Experiment Design: four treatments were used:

T0: Control (without salinity)

T1: NaCl 50 meq

T2: NaCl 150 meq

T3: NaCl 200 meq

The size of the pots was 20 cm width and 18 cm depth. Soil composition was a mixture of organic matter and sand in the following proportions; 2/3: 1/3.

Plantules that have been transferred in pots received 250 ml each, which correspond to field capacity. Seedlings were exposed to salt stress for four (4) weeks; observations were then recorded and physiological analysis were run.

Analysis

Biomass: it was quantified in weight of fresh and dry matter. Entire plant, shoot and root were weighted. Dry matter was obtained after 24 hours at 85°C in a laboratory oven.

Chlorophyll content: it was performed according to Mc Kinney & Arnon (1949).

Prolin content: the analysis was run according to Monneveux & Nemmar (1986).

Soluble sugars content: according to Shields & Burnett (1960).

Statistical analysis: according to Dunnett (1964)

RESULTS AND DISCUSSION

Effect of salinity according to Dunett test

As far as results are concerned (Fig. 1), it appears that plants respond positively to salt gradient. Most favorable levels seem to be T1 and T2. In a general manner, except for root biomass which remains stable, *Atriplex* L. show its ability of halophytic species. This positive responses obtained in T1 and T2 could have been a result of biochemical mechanism that increased Fresh Matter yield. The salinity level T1 and T2 could have been also considered as sort of mineral nutrient for seedlings. Beyond these levels, salinity become harmful eventough *Atriplex* seems to sustain salt concentrations.

As shown in Figure 2, dry matter weight is similar to fresh weight, as far as salinity levels are con-

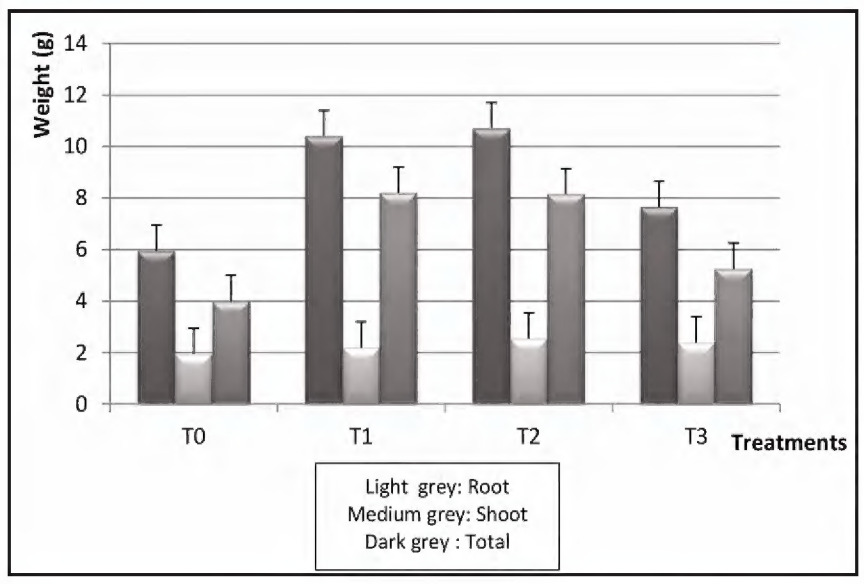

Figure 1. Fresh matter weight in *Atriplex canescens* according to salinity levels.

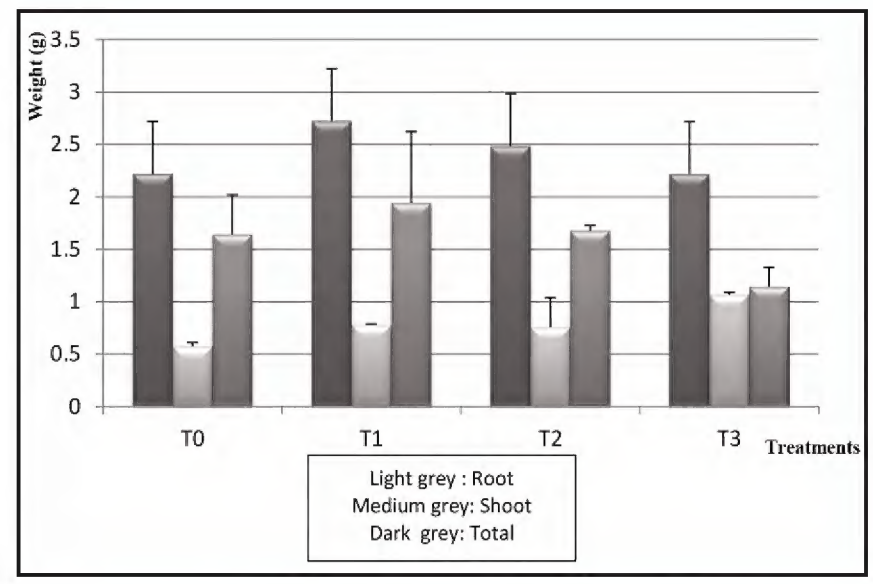

Figure 2. Dry matter weight in *Atriplex canescens* according to salinity levels.

	Total Fresh Matter		Shoot Fresh Matter		Root Fresh Matter	
	mean	probability	mean	probability	mean	probability
T_0	5.90	0.104	4.000	0.098	1.950	0.149
T_1	10.400	Non	8.200	Non	2.200	Non
T_2	10.700		8.150		2.550	
T_3	7.650	Significant	5.250	Significant	2.400	Significant

Table 1. Fresh matter weight analysed by Dunett test.

	Total Dry Matter		Shoot Dry Matter		Root Dry Matter	
	mean	probability	mean	mean	probability	mean
T_0	2.218	0.468	1.641	0.184	0.576	0.017*
T_1	2.723	Non	1.942	Non	0.783	
T_2	2.486		1.676		0.759	Significant
T_3	2.217	Significant	1.145	Significant	0.070	

Table 2. Dry matter weight analysed by Dunett test.

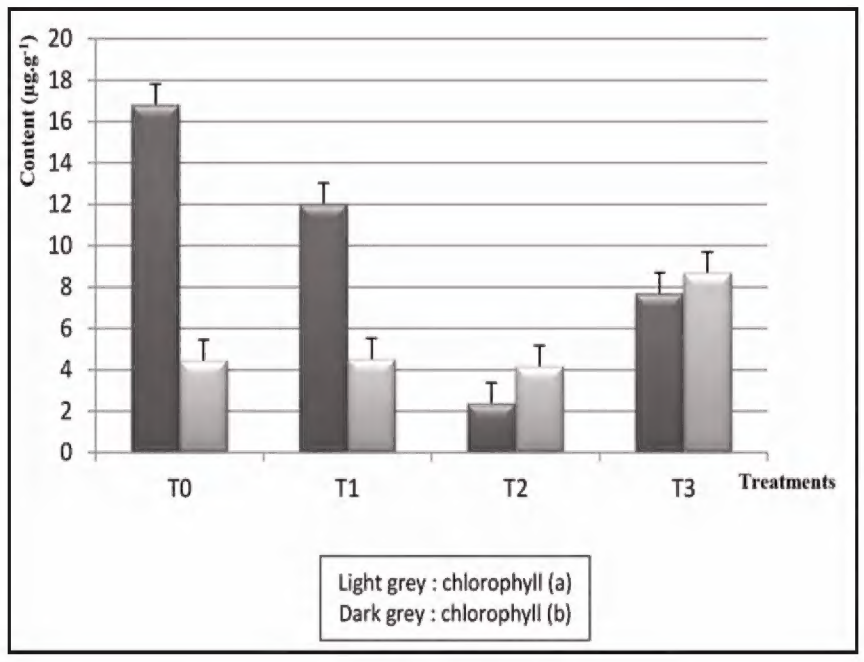

Figure 3. Chlorophyll content in *Atriplex canescens* according to a salinity gradient.

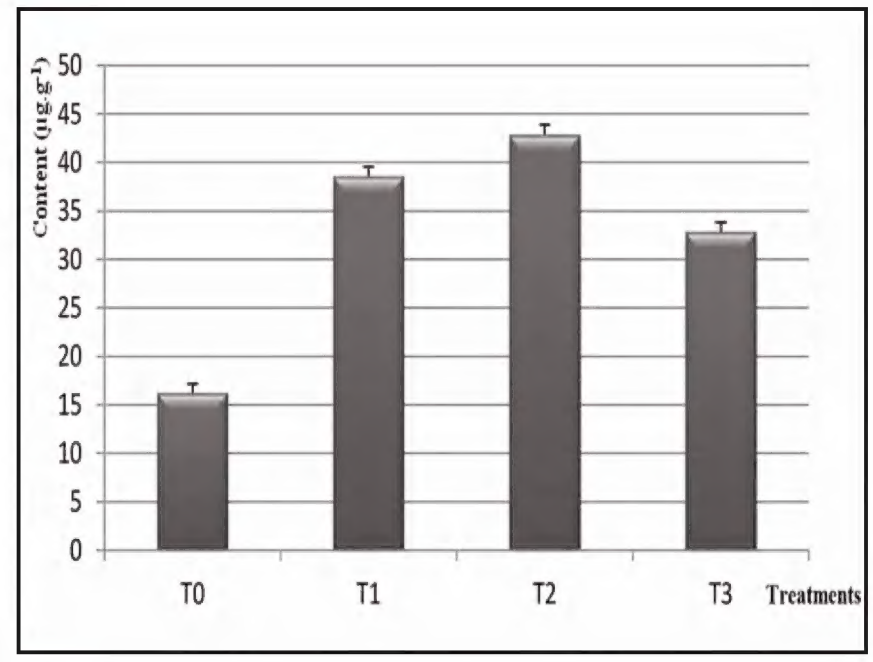

Figure 4. Proline accumulation in *Atriplex canescens* according to a salinity gradient.

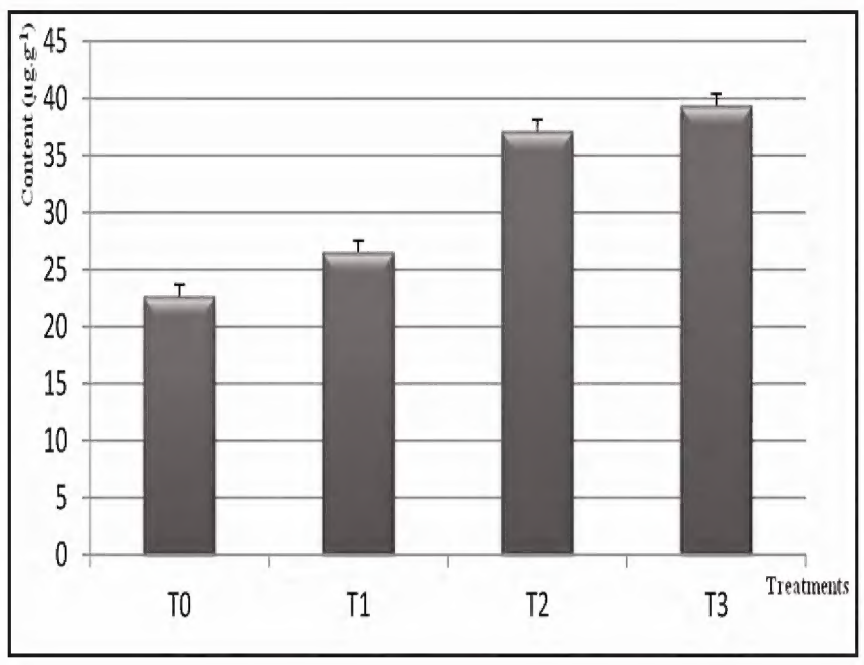

Figure 5. Total proteins accumulation in *Atriplex canescens* according to salinity levels.

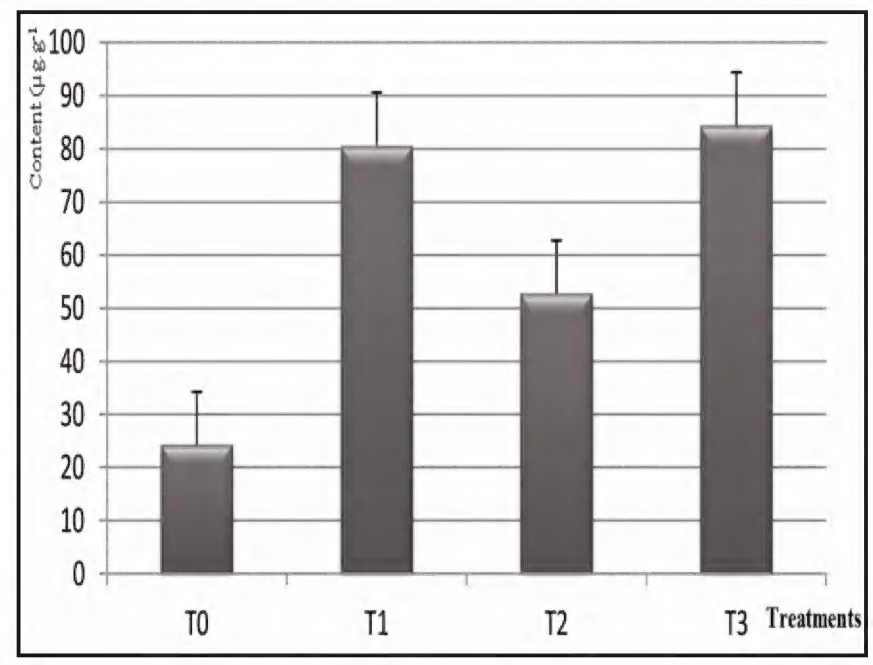

Figure 6. Soluble sugars accumulation in *Atriplex canescens* according to a salinity levels.

	Chlorophyll (a)		Chlorophyll (b)	
	Mean	Probability	Mean	Probability
T_0	16.27	0.003**	4.44	0.002**
T_1	12.02	Highly	4.51	Highly
T_2	2.06	Significant	4.11	Significant
T_3	7.69		8.69	

Table 3. Chlorophyll content analysed by Dunett test.

	Mean	Probability
T_0	16.15	0.000***
T_1	38.5	Very highly
T_2	42.82	Significant
T_3	32.85	

Table 4. Proline accumulation analysed by Dunnet test.

	Mean	Probability
T_0	22.68	0.000***
T_1	26.56	Very highly
T_2	37.16	Significant
T_3	39.4	

Table 5. Total Proteins accumulation analysed by Dunett test.

	Mean	Probability
T_0	24.3	0.025*
T_1	80.69	
T_2	52.84	
T_3	84.53	

Table 6. Soluble Sugars accumulation analysed by Dunnett test.

cerned. Treatments T1 and T2 had accumulated more biomass for shoot. As far as roots are concerned, salinity did not show important incidence for biomass yield (dry matter).

Chlorophyll content

A decrease in chlorophyll content was observed except for T3 (Fig. 3). This helps us to understand that *A. canescens* uses other adaptative mechanisms to salt stress.

Table 3 shows That different treatments had high significant difference for chlorophyll (a); (0.003**) and chlorophyll (b); (0.002**).

Osmoprotectors - Proline accumulation

In figure 4, when salinity stress is increased, proline accumulation increased too. Because of this increase, *A. canescens* proved to behave as halophytic species. Satistical analysis shows very high significant differences between treatments. This might be due to endogenic ability of *A. canescens* to sustain high salinity level (T3).

Selection of tolerant cultivars could be based on such performance; as far as osmoregulation is concerned.

Total proteins

High NaCl concentrations stimulated protein accumulation. Very high significant differences are obtained using Dunett test (Table 5).

Soluble Sugars

Except for treatment T2 (Fig. 6) High NaCl concentration has caused soluble sugar accumulation. Dunnett test show significant differences between treatments.

CONCLUSIONS

Numerous physiological mechanisms and biochemical ones are regarded as being adaptative responses to salt and constitute specific adaptative traits.

Thus, each response is translated by physiological or biochemical marker. *Atriplex* constitute an interesting model for quantitative evaluation of different yield traits. Because of it's ability to maintain soil and preserve it against erosion that may occur under drastic environmental conditions, drought in particular, *Atriplex* may play a very important role in sustainable development areas. As to wether or not salt is to be considered one of the main abiotic constraints, much has to be done and emphasized on getting new tools of adaptative strategies. *Atriplex* is among those suitable solutions because of its capacity of covering soils, preventing them from erosion and constituting a substantial nutritional value as well, for sheep mainly.

On the basis of these indirect tests, which are physiological and biochemical ones, it appears that some of them can be of great reliable interest. The exploration of how the species behave to face to salt

stress, helps us in selecting determinant traits worth to be incorporated in breeding programs.

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Gastrointestinal helminth parasites of *Lithognathus mormyrus* (Linnaeus, 1758) (Perciformes Sparidae) in the Western Mediterranean Sea

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ABSTRACT

Between December 2014 and April 2016, 235 specimens of striped seabream *Lithognathus mormyrus* (Linnaeus, 1758) (Perciformes Sparidae) caught along the western Algerian coast were examined for helminth parasites. This taxa includes 5 monogeneans (*Lamellodiscus flagellatus*, *L. ignoratus*, *L. mormyri*, *L. verberis* and *Pagellicotyle mormyri*), 13 digeneans (*Lepidauchen stenostoma*, *Derogenes latus*, *Magnibursatus bartolii*, *Proctoeces maculatus*, *Holorchis pycnoporus*, *Lepocreadium album*, *L. pegorchis*, *Macvicaria maamouriae*, *M. maillardi*, *M. mormyri*, *Pycnadenoides senegalensis*, *Diphterostomum brusinae* and *Zoogonus rubellus*), 3 nematodes (*Hysterothylacium rhacodes*, *Dichelyne tripapillatus* and *Ascarophis* sp.), 1 cestode (*Scolex pleuronectis*) and 2 Acanthocephala (*Acanthocephaloides propinquus* and *A. incrassatus*). All the species were recorded for the first time in the western Algerian coast in this host. Furthermore, *Lepidauchen stenostoma* and *Hysterothylacium rhacodes* are reported for the first time in the western Mediterranean. *Magnibursatus bartolii*, *Zoogonus rubellus*, *Dichelyne tripapillatus*, *Ascarophis* sp. and *Scolex pleuronectis* provide a new host record in *Lithognathus mormyrus* from the Mediterranean Sea. Epidemiological indexes (prevalence, abundance and mean intensity) were calculated for each helminth species identified in this fish. The Algerian west coast shows the highest value in the helminth species richness among all the Mediterranean coasts.

KEY WORDS

Helminthfauna; *Lithognathus mormyrus*; Mediterranean Sea; Sparidae.

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INTRODUCTION

The Sparidae Rafinesque, 1810 (Pisces Perciformes) form a family of fish that include more than 100 species worldwide. They are demersal fish that live in coastal waters and occupy a variety of trophic niches (Bargelloni et al., 2005). One of the sparids found in Algeria is the striped sea bream *Lithognathus mormyrus* (Linnaeus, 1758), the only species of the genus *Lithognathus* Swainson, 1839, recognized to date in the area. It is a gregarious species that lives in groups on sandy and muddy bottoms, as well as on prairies and estuaries, up to 80 meters (Mediterranean Sea) and 150 meters (Atlantic Ocean) in depth (Bauchot & Hureau, 1986, 1990; Pajuelo et al., 2002). *Lithognathus mormyrus* is very mobile, but very dependent on the sea bottoms in which it gets its food (Hammami et al., 2013). It is carnivorous, looking for worms, molluscs, small crustaceans and debris (Russell et

al., 2014). Its excellent meat makes it a commercially important fish. *Lithognathus mormyrus* is widely distributed along the coasts of the Mediterranean and is present in the Atlantic Ocean from the bay of Bicay to the promontory of Good Hope, the Red Sea. This species is also found in the Western Indian Ocean and the Black Sea (Bauchot & Hureau, 1990; Kallianiotis et al., 2005).

The parasitic fauna of *L. mormyrus* has been studied in several areas: the Western Mediterranean Sea (Euzet, 1984; Oliver, 1987; Bartoli et al., 1989; Bartoli et al., 1993; Bartoli & Bray, 1996; Jousson et al., 1999; Sasal et al., 1999; Jousson et al., 2000; Benmansour et al., 2001; Jovelin & Justine, 2001; Desdevises et al., 2002; Bartoli et al., 2005; Ramdane et al., 2007; Gargouri Ben Abdallah & Maamouri, 2008; Boudaya et al., 2009; Ramdane et al., 2009; Boualleg et al., 2010, 2011; Gargouri Ben Abdallah et al., 2011; Poisot et al. , 2011; Derbel et al., 2012; Samn et al., 2014; Antar et al., 2015; Gargouri Ben Abdallah et al., 2015); the Eastern Mediterranean Sea (Deardorff & Overstreet, 1978; Saad Fares & Maillard, 1990; Saad-Fares & Combes, 1992a, b; Bruce et al., 1994; Akmırza, 2010; Cafer et al., 2015; Demirkale et al., 2015); other undefined areas of the Mediterranean Sea (Bray & Cribb, 1997; Desdevises, 2001); Adriatic (Radujkovic & Raibaut, 1989a, b; Radujkovic & Euzet, 1989; Orecchia et al., 1988; Desdevises, 2001; Radujkovic et al., 1989; Bray & Bartoli, 1996); the North-Eastern Atlantic Ocean (Gijon-Botella & Lopez-Roman, 1989); the South-Eastern Atlantic Ocean (Gaevskaya & Aleshkina, 1988); the Aegean Sea (Akmirza, 2013; Çinar, 2014) and the Red Sea (Bray & Cribb, 1989).

To date, there are no detailed reports on the communities of helminth parasites along the Algerian coasts. The aim of this study is to describe and characterize the helminth fauna of *L. mormyrus* that inhabits the Oran Bay (North-Western Algeria), thus contributing to the knowledge of the biodiversity of the region.

MATERIAL AND METHODS

From December 2014 to April 2016, 235 specimens of *L. mormyrus* from the Oran bay (35° 43' N - 0° 37' W) (Fig. 1) were collected in order to determine the helminth fauna of this host. The caught fishes were transported as quickly as possible to the laboratory in an isotherm container. Each specimen was measured, weighed and dissected. All organs, including visceral parts were removed and carefully checked for parasites. Helminth parasites were examined and identified under a binocular microscope. The sites of each parasite species were noted. For the taxonomic studies, the nematodes were relaxed and cleaned in a petri dish, then fixed and stored in a mixed solution of glycerine (50 ml) and ethanol 70% (950 ml). Acanthocephala, Cestoda, Digenea and some Monogenea were fixed in 70% ethanol, stained with iron acetocarmine, dehydrated through a graded alcohol series, cleared in dimethyl phthalate and finally examined as permanent mounts in Canada balsam. Other Monogenea were transferred individually onto a slide in a drop of ammonium picrate-glycerine (APG) (Malmberg, 1957). Calculation of the infection parameters related to prevalence, mean intensity and abundance was based on the work of Bush et al. (1997).

RESULTS

In this set of 235 *L. mormyrus* analyzed specimens, 24 helminth parasite species were collected. Their list, life stage and infection site in the hosts are presented in the Table1. There are: 5 species of Monogenea of which 4 Monopisthocotylea (*Lamellodiscus flagellatus*, *Lamellodiscus ignoratus*, *Lamellodiscus mormyri* and *Lamellodiscus verberis*) and 1 Polyopisthocotylea (*Pagellicotyle mormyri*); 13 species of Digenea (*Lepidauchen stenostoma*, *Derogenes latus*, *Magnibursatus bartolii*, *Proctoeces maculatus*, *Holorchis pycnoporus*, *Lepocreadium album*, *L. pegorchis*, *Macvicaria maa mouriae*, *M. maillardi*, *M. mormyri*, *Pycnadenoides senegalensis*, *Diphterostomum brusinae* and *Zoogonus rubellus*); 3 species of Nematoda (*Hysterothylacium rhacodes*, L3, L4 stage larvae and adults, *Dichelyne tripapillatus*, adult stage and *Ascarophis* sp., adult stage); 1 species of Cestoda (*Scolex pleuronectis*, larval stage) and 2 species of Acanthocephala (*Acanthocephaloides propinquus* and *A. incrassatus*).

The Digenea are the dominant group of helminths and show a high species diversity. The study of these parasites distribution within the host di-

gestive tract showed that *Derogenes latus* occupies the gall blader, *Magnibursatus bartolii* is localized at the stomach level and *Proctoeces maculatus* in the rectum. The majority of the trematodes seems to show clear ecological preference and limits its distribution to only one niche, in this case the intestine. *Holorchis pycnoporus* has the highest prevalence, mean intensity and abundance (P%= 61.27, A= 2.99, MI= 4.88).

The 5 monogenean species were detected only in the gills of *L. mormyrus*, the highest infestation rate being found for *Lamellodiscus ignoratus* at 84.89%. The highest mean infestation intensity exceeds 4 parasites per fish as found for *Lamellodiscus mormyri*, whereas the highest abundance value is recorded for *L. mormyri* (2.28).

The 3 Nematoda taxa were found only in the intestine, except for *Hysterothylacium rhacodes,* which were also observed in the connective tissues of the visceral cavity with a high prevalence (29.78%) and abundance (0.56). *Dichelyne tripapillatus* presented the highest mean intensity of 2.34 and *Ascarophis* sp. the lowest prevalence.

Larvae of *Scolex pleuronectis* (Cestoda) occurred only in the intestine with the following infection values: P%= 3.40; A= 0.05 and MI= 1.62.

The 2 Acanthocephala, *Acanthocephaloides propinquus* and *A. incrassatus*, were detected only in the rectum with a prevalence of 5.10 and 1.27, respectively.

DISCUSSION

The diversity of Digenea in *L. mormyrus* is more important in the Oran bay than in any other localities of the Mediterranean Sea. The successful completion of the life cycles of these parasites in the Oran bay may be due to a confined environment that limits the dispersion of the larval stages. The biodiversity, environment, and stability of the site can also contribute to this richness of digeneans. Indeed, a high level of digenean diversity in the Scandola Nature Reserve (Corsica) has been related to the equilibrium stability of the ecosystem that is devoid of major pollutants and opens directly to the Western Mediterranean basin (Bartoli et al., 2005). Also, environmental factors are important in determining parasitic fauna (Holmes, 1990). They may be the living environment, pelagic or benthic living conditions, coastal life, temperature and physico-chemical conditions of water (Polyanski, 1961; Rohde, 1978; Campbell, 1983; Moller, 1997). It should be noted though that Gargouri Ben Abdallah et al. (2011) revealed the presence of *Allopodocotyle pedicellata* (Stossich, 1887) in *L. mormyrus* from the Bizerte lagoon, whereas this parasite was not collected in this investigation. Its absence might be attributed to the rarity of this parasite or the absence of different intermediate hosts.

Since the majority of Digenea (*Lepidauchen stenostoma*, *Holorchis pycnoporus*, *Lepocreadium album*, *L. pegorchis*, *Macvicaria maamouriae*, *M. maillardi*, *M. mormyri*, *Pycnadenoides senegalensis*, *Diphterostomum brusinae* and *Zoogonus rubellus*) was recorded in the intestine, it constitutes the preferred habitat probably in relation to the host diet. In fact, since it presents the greatest surface area in comparison to the other organs of the studied fish and the most nutrient-rich site, it influences the parasite specificity towards the host. Smith (1981) reported that most parasites inhabit the intestine because of their general feeding habits. As pointed out by Holmes (1990), the use of nutrients by pests constitutes one of the major regulating parameters for the competition among the intestine parasites. According to Sasal et al. (1999), it is the main factor affecting parasite community structure, especially for digenean trematodes that are transmitted to their final host through a predator-prey relationship. Indeed, according to Froese & Pauly (2014) and Fischer et al. (1987), *L. mormyrus* feeds on worms, mollusks and small crustaceans. However, some species are limited to the stomach (*Magnibursatus bartolii*), rectum (*Proctoeces maculatus*) or gall bladder (*Derogenes latus*). The movement of the stomach muscle and the hydrochloric acid it contains may lead to a reduced number of the parasites in it (Akinsanya et al., 2008). According to Ricklefs & Schluter (1993), as some parasites are limited to a microbiotope, it results in the presence of a physical or chemical barrier difficult to cross by other digeneans. Indeed, a key factor in niche restriction processes is intra- and inter-specific competition (Holmes, 1990; Sukhdeo & Sukhdeo, 1994; Dezfuli et al., 2002).

The examination of the ecological terms shows that *Holorchis pycnoporus* and to a lesser degree *L. pegorchis* and *M. mormyri* seem to be the most frequent parasites. The former was recorded in many different regions of the Mediterranean Sea

Lithognathus mormyrus **(N=235) infected by:**	**Stage**	**Site**	**P(%)**	**A**	**MI**
MONOGENEA					
Pagellicotyle mormyri (Lorenz, 1878)	A	G	22.97	0.45	2
Lamellodiscus flagellatus Boudaya, Neifar et Euzet, 2009	A	G	31.06	0.78	2.53
Lamellodiscus ignoratus Palombi, 1943	A	G	54.89	1.86	3.40
Lamellodiscus mormyri Euzet et Oliver, 1967	A	G	51.91	2.28	4.40
Lamellodiscus verberis Euzet et Oliver, 1967	A	G	20.85	0.52	2.51
DIGENEA					
Lepidauchen stenostoma Nicoll, 1913	A	I	28.51	0.44	1.55
Derogenes latus Janiszewska, 1953	A	GB	3.40	0.07	2.12
Magnibursatus bartolii Kostadinova, Power, Fernandez, Balbuena, Raga et Gibson, 2003	A	S	7.23	0.22	3.05
Proctoeces maculatus (Looss, 1901)	A	R	4.68	0.06	1.36
Holorchis pycnoporus Stossich, 1901	A	I	61.27	2.99	4.88
Lepocreadium album (Stossich, 1890)	A	I	8.93	0.18	2.09
Lepocreadium pegorchis (Stossich, 1901)	A	I	49.97	1.31	3.05
Macvicaria maamouriae Antar, Georgieva, Gargouri et Kostadinova, 2015	A	I	2.55	0.03	1.5
Macvicaria maillardi Bartoli, Bray et Gibson, 1989	A	I	5.53	0.07	1.30
Macvicaria mormyri (Stossich, 1885)	A	I	44.25	0.94	2.13
Pycnadenoides senegalensis Fischthal et Thomas, 1972	A	I	2.97	0.02	1
Diphterostomum brusinae (Stossich, 1889)	A	I	18.29	0.54	2.95
Zoogonus rubellus (Olsson, 1868) Odhner, 1902	A	I	6.80	0.11	1.62
NEMATODA					
Hysterothylacium rhacodes (Deardorff et Overstreet, 1978)	AL	VCI	29.78	0.56	1.9
Dichelyne tripapillatus (Gendre, 1927)	A	I	23.40	0.54	2.34
Ascarophis sp.	A	I	2.55	0.02	1
CESTODA					
Scolex pleuronectis Müller, 1788	L	I	3.40	0.05	1.62
ACANTHOCEPHALA					
Acanthocephaloides propinquus (Dujardin, 1845)	A	R	5.10	0.07	1.5
Acanthocephaloides incrassatus (Molin, 1858)	A	R	1.27	0.02	1.66

Table 1. Infection parameters of striped seabream (*Lithognathus mormyrus*) from the Oran bay. Abbreviations: P% = prevalence; A= abundance; MI= mean intensity; A= adult; L= larva; G= gills; I= intestine; GB= gall blader; S= stomach; R= Rectum; VC= Visceral cavity.

(Orecchia et al.,1988; Radujkovic & Raibaut, 1989; Radujkovic et al., 1989; Bartoli & Bray, 1996; Bray & Cribb, 1997; Sasal et al., 1999; Akmirza, 2000).

Furthermore, *Holorchis pycnoporus* is the most prevalent and abundant and has the highest mean intensity of trematode species. This result agrees with studies carried out on the *L. mormyrus* in other parts of the Mediterranean Sea (Bartoli et al., 2005; Gargouri Ben Abdallah & Maamouri, 2008; Gargouri Ben Abdallah et al., 2011; Derbel et al., 2012).

The 9 species of Trematodes (*Derogenes latus*, *Proctoeces maculatus*, *Lepocreadium album*, *L. pegorchis*, *Macvicaria maamouriae*, *M. maillardi*, *M. mormyri*, *Pycnadenoides senegalensis* and *Diphte-*

rostomum brusinae) recorded in the present study were already detected in different Mediterranean areas (Orecchia et al., 1988; Bartoli et al., 1989; Radujkovic & Raibaut, 1989a; Radujkovic et al., 1989; Saad Fares & Maillard, 1990; Saad-Fares & Combes, 1992a, b; Bartoli et al., 1993; Sasal et al., 1999; Jousson et al., 1999; Jousson et al., 2000; Bartoli et al. 2005; Gargouri Ben Abdallah & Maamouri, 2008; Gargouri Ben Abdallah et al., 2011; Derbel et al., 2012; Antar et al., 2015). In contrast, *Lepidauchen stenostoma*, *Magnibursatus bartolii* and *Zoogonus rubellus* were observed only among *L. mormyrus* from the Oran bay, although the first one was already described as a parasite of *L. mormyrus* in the Adriatic Sea off the coast of Montenegro (Bray & Bartoli, 1996). *Magnibursatus bartolii* was already encountered in: *Boops boops* (Linnaeus, 1758), another sparid species from the North-east Atlantic coast, Spain (Kostadinova et al., 2003); *Oblada melanura* (Linnaeus, 1758) from the Gulf of Tunis (Gargouri Ben Abdallah & Maamouri, 2008); *Sparus aurata* (Linnaeus, 1758) from the Bizerte Lagoon (Gargouri Ben Abdallah et al., 2011); *Diplodus sargus* (Linnaeus, 1758) off the coast of Buriana, Spain (Kostadinova & Gibson, 2009) and *D. sargus* from the Oran bay (Bellal et al., 2016).

Similary, *Zoogonus rubellus* has been reported in several fish species belonging to the Sparidae family in: the Southeast Atlantic (Parukhin, 1966); Corsica (Jousson et al., 1999; Sasal et al., 1999; Bartoli et al., 2005); the Gulf of Tunis (Gargouri Ben Abdallah & Maamouri, 2008); the Bizerte Lagoon (Antar & Gargouri Ben Abdallah, 2013.) and also the Oran bay (Bellal et al., 2016). Hence, we report them here for the first time in *L. mormyrus* from the western Mediterranean.

The evaluation of the parasite indices as seen on the table reveals that it is the Monopisthocotylea that records the highest values. The difference observed between the two subclasses may be due to the large size of the Polyopisthocotylea which increases the spatial competition in the gills of the infested fish. According to Combes (1995), high parasite loads may indicate that the host provides better habitat, and it means that parasite/host encounters are easier and compatibility is possible.

Among Monogenea, there were five most frequent species detected of which four *Lamellodiscus* Johnston et Tiegs, 1922, *L. ignoratus* being the dominant species with a prevalence of 54.89%. The latter was already reported in *L. mormyrus* by: Radujkovic & Raibaut (1989a) in Southern Adriatic Sea; Desdevises (2001) off the French coast of the Mediterranean Sea and Boudaya et al. (2009) off Sète (France) and Sfax (Tunisia). It has also been found in other sparid species (Oliver, 1987; Radujkovic & Euzet, 1989; Desdevises et al., 2002; Amin & Euzet, 2005; Amine et al., 2006, 2007a, b; Poisot et al., 2011; Kouachi et al., 2012). *Lamellodiscus mormyri* and *L. verberis* were found in *L. mormyrus* by Euzet (1984), Oliver (1987), Radujkovic & Euzet (1989), Desdevises (2001) and Boudaya et al. (2009). The *Lamellodiscus flagellatus* presence on the gills of *L. mormyrus* was detected off Sète (France) and Sfax (Tunisia) by Boudaya et al. (2009). With regards to *Pagellicotyle mormyri*, it was observed in the same host in Italy (Lorenz, 1878; Monticelli, 1888; Parona & Perugia, 1889, 1890), France (Marc, 1963), Tunisia (Ktari, 1971; Neifar, 1995) and the Gulf of Annaba, Algeria (Kaouachi, 2010). It should be noted that these five species were recorded in *L. mormyrus* for the first time in the Oran bay.

This is the first report of the occurrence of *Hysterothylacium rhacodes* (Nematoda) in larvae L3, L4 as well as adult stages in *L. mormyrus* from the Western Mediterranean Sea. However, they have been previously reported in the same host from the Eastern Mediterranean Sea (Deardorff & Overstreet, 1978; Bruce et al., 1994).

Dichelyne tripapillatus was encountered in another sparid species, *Diplodus sargus* from the Adriatic Sea (Radujkovic & Raibaut, 1989a; Petter & Radujkovic, 1989). The present work provides a new host (*L. mormyrus*) record for it, as well as for *Ascarophis* sp. in the Mediterranean Sea. This last species has a low prevalence and could be accidentally present on this host.

Scolex pleuronectis (Tetraphyllidean) larvae constitute the first report in Mediterranean *L. mormyrus* from the Oran bay. It is nevertheless reported in various sparid species in many other areas (Joyeux & Baer, 1936; Euzet, 1956; Parukhin, 1976; Renaud et al., 1980; Anato et al., 1991; Khalil et al., 1994; Naidenova & Mordvinova, 1997; Akmirza, 1998, 2000; Paraguassu et al., 2002; Luque & Poulin, 2004; D'Amico et al., 2006; Pérez-del-Olmo et al., 2007a, b, 2008; Marzoug, 2012).

Concerning the Acanthocephalan species, *Acanthocephaloides propinquus* and *A. incrassatus* were detected for the first time in the Oran bay. Gargouri

Ben Abdallah et al. (2015) reported in the studied host from the Bizerte lagoon the presence of three acanthocephalan species, *Acanthocephaloides propinquus*, *A. incrassatus* and *Neoechinorhynchus* (*Neoechinorhynchus*) *rutili*. *Acanthocephaloides incrassatus* has already been reported in *Pagellus erythrinus* (Linnaeus, 1758) from Corsica (Ternengo et al., 2005) and *A. propinquus* in *Diplodus annularis* from the Gulf of Cagliari (D'Amico et al., 2006).

The data gathered in this study show that all the parasite species recognized in *L. mormyrus* from the Oran bay were already reported in this fish specimen from different areas of the Mediterranean Sea, except for *Lepidauchen stenostoma*, *Magnibursatus bartolii*, *Zoogonus rubellus*, *Dichelyne tripapillatus*, *Ascarophis* sp. and *Scolex pleuronectis* for which new records for this Mediterranean striped seabream population are established. Hence, the greatest helminth parasitic richness is found in the Oran bay.

Some ecological studies on fish parasites have suggested that many parameters influence parasite species diversity such as: body size, habitat, distributional range as well as feeding and schooling habits (Morand et al., 1999; Rodhe, 2010; Timi et al., 2010). Experimentation conditions (Walther et al., 1995) pointed out that many elements may affect directly or indirectly specific richness including the efforts of individuals examining hosts and variables related to the phylogeny of hosts and parasites (Bush et al., 1997; Poulin, 1995; Guegan & Morand, 1996; Sasal et al., 1997). All these factors increase the likelihood to encounter more parasite species.

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Reproductive cycle of the gilthead sea bream *Sparus aurata* Linnaeus, 1758 (Pisces Perciformes Sparidae) in the Gulf of Skikda (Algerian East coast)

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ABSTRACT

Specimens of the gilthead sea bream *Sparus aurata* Linnaeus, 1758 (Pisces Perciformes Sparidae) have been the subject of a study on the reproductive biology in the Gulf of Skikda, which extends from Cape Bougaroune (06°27'10"E) to Cape of Iron (07°10'02"E), from March 2014 to February 2015, in order to describe the sex distribution, sexual cycle and size at first sexual maturity. A total of 576 specimens of which 391 males and 185 females were analyzed. The numerical proportion of males (68%) differs significantly from that of females (32%) ($\varepsilon > 1.96$, $\alpha = 5\%$). The gonadosomatic (GSI) and hepatosomatic (HSI) indices of females and males indicate a single reproduction period. This Spawning period ranges from December to January. Oocyte maturation occurs when the HSI is high. On the other hand, spawning causes a decrease in the HSI. The size at first sexual maturity (Lm50) is 18.3 cm for males and 19.6 cm for females.

KEY WORDS Algerian East coasts; reproductive biology; sex distribution; *Sparus aurata*.

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INTRODUCTION

The gilthead sea bream *Sparus aurata* Linnaeus, 1758 (Pisces Perciformes Sparidae) has an economical importance both in Algeria and throughout the Mediterranean Sea. Thus, numerous studies have been devoted to its study, notably concerning its biology (Lasserre & Labourg, 1974; Arnal et al., 1976; Lasserre, 1976; Suau & López, 1976; Ferrari & Chieregato, 1981; Wassef & Eisawy, 1985; Rosecchi, 1985; Mosconi & Chauvet, 1990; Magoulas et al., 1995; Pita et al., 2002; Stergiou & Karpouzi, 2002; Almuly et al., 2005; Rossi et al., 2006; Parati et al., 2011).

On the coast of Algeria, fishing of S. aurata is mainly assured by trawl, trammel, gillnets and palangrots. The last three gears target *S. aurata* even during periods of restricted trawl fishery, from May to August, suggesting a possible overexploitation of its stock and a scarcity of spawners. For this reason, the study of the renewal of populations is essential and knowledge of the phenomena related to the reproduction of species is of fundamental interest.

In Algeria, the gilthead sea bream has been the subject of some studies in the lagoon environment (Chaoui et al., 2005; Chaoui et al., 2006; Chaoui et al., 2009; Chaoui et al., 2012). However, its reproductive biology in marine environment has never

been studied. In our research on the biology of S. aurata from the catches of the Gulf of Skikda (Algeria), it is important to characterize its reproductive cycle.

The present work aims to better know the different phases of the reproductive cycle of *S. aurata* and to determine its size at first sexual maturity in a natural environment.

MATERIAL AND METHODS

Sampling of this study was possible thanks to the catches of the commercial fishing fleet of the Gulf of Skikda (Algeria) (Fig. 1). Sampled specimens of the gilthead sea bream come from private trawlers. During the period from March 2014 to February 2015, a total of 576 specimens were collected (391 males and 185 females).

For each specimen sampled, sex and total length (Lt) were expressed in cm with an accuracy of 1 mm. Total weight (Wt), eviscerated weight (We), gonad weight (Wg) and liver weight (Wf) were expressed in g with an accuracy of 0.01 g and recorded. The hermaphrodite individuals in the process of sex change are characterized by sex of which the gonad is the most developed (Anonymous, 1998).

The maturity stages of the gonads were determined using the scale proposed by Hadj-Taieb et al. (2013):

Stage I (immature or sexual rest): the testes are whitish, with a round section and a few blood vessels. The ovaries are transparent, slightly pinkish and filamentous with fine membrane; the vascularization is barely visible.

Stage II (beginning of maturation): the testes are milky white with a flat section leaving to flow no liquid into the incision. The ovaries are less transparent, better vascularized and yellowish in color; the oocytes are visible to the naked eye.

Stage III (full maturation): the testicles are more voluminous, in knife blade, leaving to flow whitish semen into incision and pressure on the abdomen. The ovaries are orange-yellow and very big; the oocytes are clearly visible with a net cytoplasmic membrane.

Stage IV (sperm emission / spawn): the testicles are big and soft, releasing milt with many lumps. The ovaries are highly vascularized with translucent ova perfectly individualized and expelled at the lesser pressure on the abdomen.

Stage V (post-emission/post-spawn): the testes are exhausted, richly vascularized, leaving to flow traces of sperm giving the organ an appearance of curdled milk. The ovaries are much vascularized, empty and flaccid, dark red, with brown spots corresponding to zones of sclerosis or atresic residual oocytes.

The sex ratio, expressed in femininity and masculinity rates (Kartas & Quignard, 1984), were determined each season:

$$\text{masculinity rate} = \frac{M}{F+M} \times 100,$$

$$\text{femininity rate} = \frac{F}{F+M} \times 100,$$

where F is the number of females and M is the number of males.

Temporal variations of gonadosomatic (GSI) and hepatosomatic (HSI) indices have been followed to describe the sexual cycle and to determine the spawning period:

$$GSI = \frac{Wg}{We} \times 100,\ HSI = \frac{Wf}{We} \times 100.$$

The condition factor K (Postel, 1973) was used to express the fish condition according to seasons and sex. This condition factor was calculated according to the formula:

$$K = \frac{Wt}{Lt^3} \times 100.$$

According to Fontana & Le Guen (1969), the size of first maturity is that at which 50% of individuals are capable to reproduce. The size of first

Figure 1. Study site: Gulf of Skikda, Algeria.

maturity (Lm50) was determined for males and females. The estimate of the Lm50 was applied only on the individuals fished during the reproduction period. We calculated by sex and size class of 1 cm the percentage of mature specimens grouped from stage II of sexual maturity. A logistic function linking the proportions of mature individuals and total length was used. This function of sigmoid shape allows to follow the degree of sexual maturity according to the size and to estimate with precision the length Lm50 from the following equation (Pauly, 1980):

$$P = \frac{1}{1+e^{-r(Lt-Lm50)}}$$

with P = proportion of mature individuals; Lt = total length (cm); r being a constant.

RESULTS

Sex ratio

Seasonal distribution of the sexes according to the season (Table 1) shows a clear predominance of males in summer, autumn and winter ($\varepsilon > 1.96$, $\alpha = 5\%$), with a maximum numerical proportion in winter. The spring season shows a sex ratio in favor of females (period of sexual rest) ($\varepsilon > 1.96$, $\alpha = 5\%$). Overall, the percentage of males, which is about 68%, differs significantly from that of females (32%) ($\varepsilon > 1.96$, $\alpha = 5\%$).

The distribution of the proportions of each sex according to the size is represented in figure 2. In the females, the observed sizes are between 18 and 29.3 cm while that of the males are between 17.5 and 28.7 cm. At a size less than 22 cm, the dominance is for the males then from 23 to 24 cm the females dominate. Beyond this range up to a size of 28 cm, the proportions of the males become important. At 29 cm in total length, females dominate.

Gonado-somatic index

The figure 3 shows for both sexes, maturation of the gonads starting from the month of October; the GSI value is higher than in September with values of 0.29 for males and 0.69 for females. In December, the index reaches 1.5 and 3.23 respectively; the gonads are at their maximum weight. The spawning and emissions start causing a decrease of the GSI in January and February.

Hepato-somatic index

For females, HSI reaches its peak in November with a value of 2.2, before the maturation of the ovaries. A low value is observed in February (HSI = 0.9), from the end of the spawning period. In males, the peak of the HSI appears during the month of October, estimated at 1.15 (Fig. 4).

Condition factor K

The values of the condition coefficient K are higher for males than for females (Fig. 5). In females, the K index increases significantly between spring and summer ($\varepsilon = 4.55$, $\alpha = 5\%$) and then stabilizes at a maximum value of 0.46 between summer and autumn. In winter, the K index slowly and significantly decreases to 0.41 ($\varepsilon = 6.96$, $\alpha = 5\%$). For the males, the K factor is stable between spring and summer seasons and then increases significantly from 0.75 to 0.79 between summer and autumn ($\varepsilon = 4.45$, $\alpha = 5\%$). In winter, K significantly decreases to 0.73 ($\varepsilon = 7.73$, $\alpha = 5\%$).

Size at first sexual maturity

The results are shown graphically in the figures 6, 7. The size at first sexual maturity (Lm50) is about 18.3 cm for males and 19.6 cm for females.

DISCUSSION

The exploitation of a fish stock is possible with the proviso that the catches by the fishery remain compatible with the maintenance of the reproductive capacity of a population. In this study, we examined spawners captured in the Gulf of Skikda (Algeria).

In *S. aurata*, the sex ratio observed for all catches shows a dominance of the males (68%). This result is similar to that of Hadj-Taieb et al. (2013) in the Gulf of Gabes (Tunisia). This predominance of one sex is a relatively frequent phenomenon in many teleost fish species (Ben Slama et al., 2010; Mezedjri et al., 2013; Hadj-Taieb et al., 2013; Boufersaoui & Harchouche, 2015; Zo-

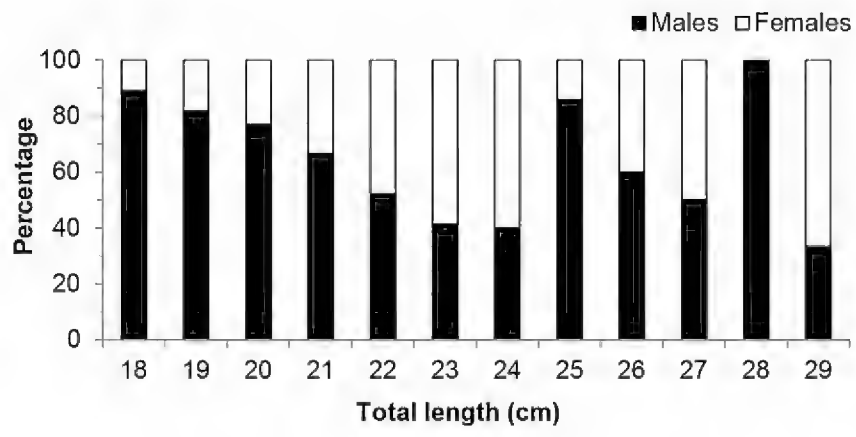

Figure 2. Length-frequency distribution of *Spaurus aurata* from the Gulf of Skikda (Algeria).

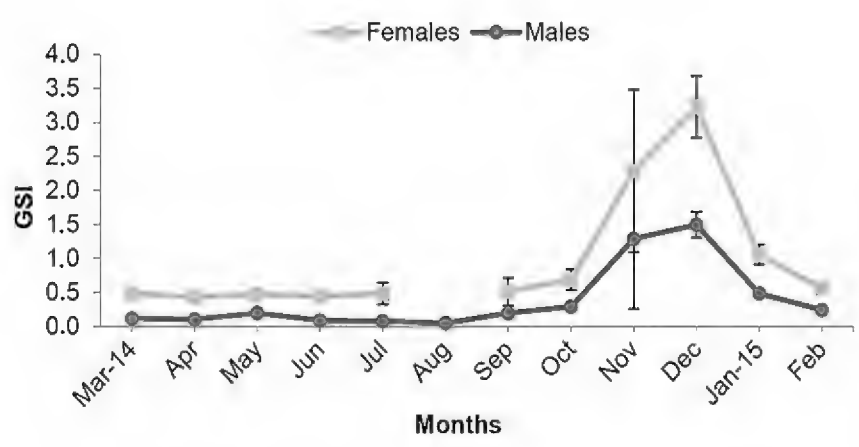

Figure 3. Variation of the gonadosomatic index for *Spaurus aurata* from the Gulf of Skikda (Algeria).

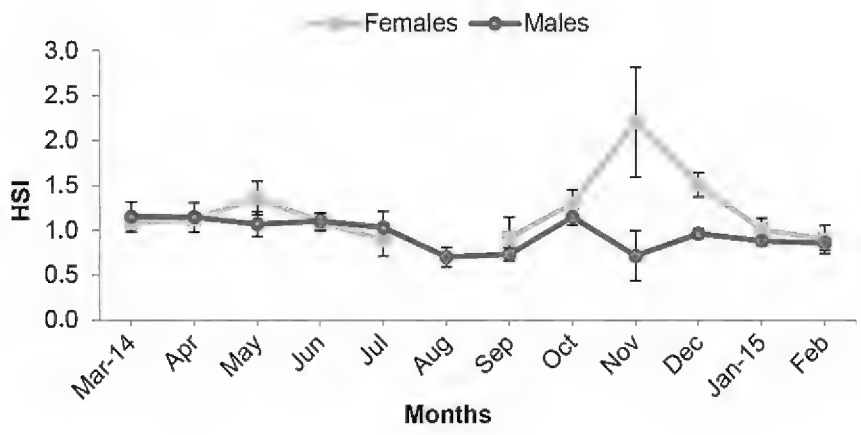

Figure 4. Variation of the hepatosomatic index for *Spaurus aurata* from the Gulf of Skikda (Algeria).

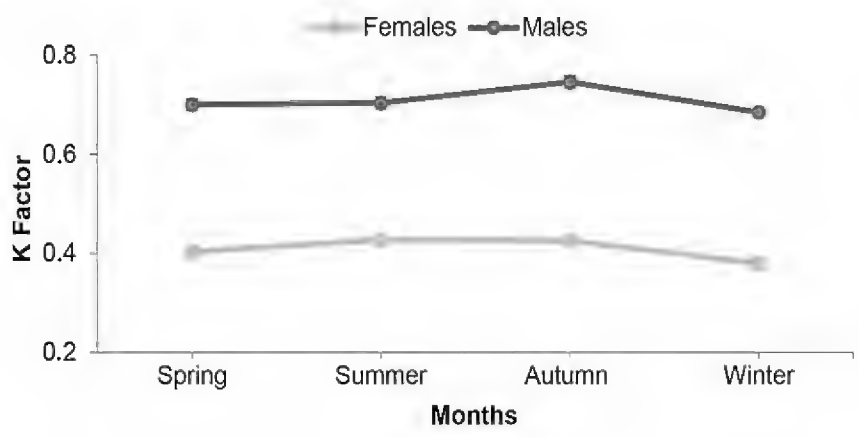

Figure 5. Variation of the condition factor (K) for *Spaurus aurata* from the Gulf of Skikda (Algeria).

uakh et al., 2016). Several hypotheses, including reproduction, displacement for food search and differential growth, may explain this trend.

The GSI allowed to follow the dynamics of the reproductive activity of *S. aurata* in the Gulf of Skikda. The reproduction period takes place over a short period; the reproduction of this species presents a single mode during an annual cycle. The reproduction period occurs from December to January. Our observations are close to those of the main authors having worked on *S. aurata* of the Mediterranean. In the Mellah lagoon (Algeria), according to Chaoui et al. (2006), spawning of *S. aurata* occurs between December and January. For Mehanna (2007), in the coasts of Port Said (Egypt), spawning spread from December to February. Hadj-Taieb et al. (2013) specify that the spawning of the gilt sea bream of the Gulf of Gabes (Tunisia) takes place from November to January.

The monthly variations of the HSI in both sexes of the sea bream on the coast of Skikda indicate that the storage of energy reserves in the liver takes place at the same time as the maturation of the gonads. The end of this last phase of the sexual cycle coincides, in the females, with the exhaustion of their liver reserves.

The seasonal evolution of the condition coefficient (K) revealed significant variations in both sexes, indicating that this coefficient is affected by the maturation of genital products. This is the case for this species of fish in the Mellah lagoon (Chaoui et al., 2006).

Knowledge of the size at first sexual maturity in fishes is essential to determine the minimum size of catch with a view to rational stock management. In *S. aurata* of the Bardawil lagoon (Egypt), Salem (2011) reported that the first sexual maturity is reached at the size of 20.5 cm for males and 22.8 cm for females. Hadj-Taieb et al. (2013) find in the Gulf of Gabes (Tunisia) a Lm50 of 17.6 cm for the males and 18.8 cm for the females. In our study, sizes of first sexual maturity are estimated to be between18.3 and 19.6 cm respectively for males and females. However, males reach sexual maturity faster than females. This would be due to the protandrous hermaphroditism observed in most sparids (Chaoui et al., 2006; Benchalel, 2010; Lechekhab et al., 2010; Hadj-Taieb et al., 2013; Boufersaoui & Harchouche, 2015).

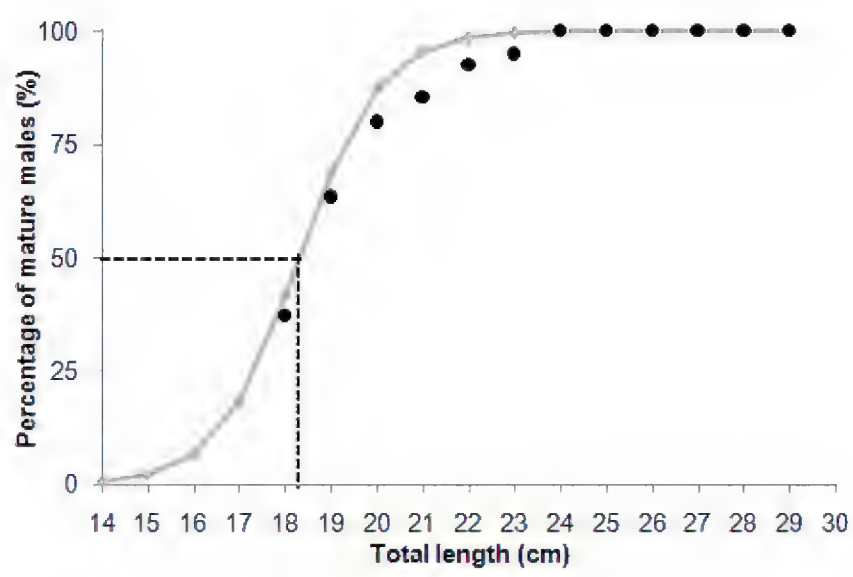

Figure 6. Size at first sexual maturity in males of *Spaurus aurata* from the Gulf of Skikda (Algeria).

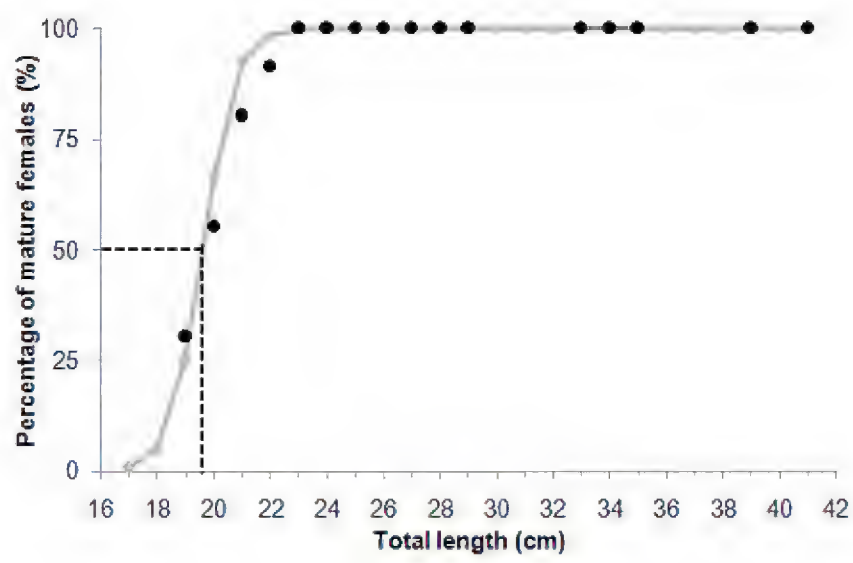

Figure 7. Size at first sexual maturity in females of *Spaurus aurata* from the Gulf of Skikda (Algeria).

In conclusion, *S. aurata* of the Gulf of Skikda spawns eggs in the winter. The warming of surface water can affect the spawning period in many marine species, including subtropical species (Boufersaoui & Harchouche, 2015). Spawning is triggered by lower water temperatures. The restriction of industrial fishing ranges from May to August according to Algerian legislation, the coastal artisanal fleet continues to target individuals during the same period. It could be recommended to limit catches of small trades in this season; fisheries management should together leave sufficient numbers of juveniles to reach sexual maturity but also preserve a substantial contribution of older females to reproduction.

ACKNOWLEDGMENTS

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Biodiversity Journal, 2018, 9 (1): 25–34

Mollusc diversity in Capo d'Armi (Central Mediterranean Sea) subtidal cliff: a first, tardy, report

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ABSTRACT First quantitative data on mollusc assemblages from the Capo d'Armi cliff, at the south entrance of the Strait of Messina, provided a baseline for monitoring changes in benthic biodiversity of a crucial Mediterranean area, whose depletion might already be advanced. A total of 133 benthic taxa have been recorded, and their distribution evaluated according to depth and seasonality. Bathymetric distribution showed scanty differences between the 4-6 meters and 12-16 meters depth levels, sharing all the 22 most abundant species. Season markedly affected species composition, since 42 taxa were exclusively recorded in spring and 35 in autumn, contrary to 56 shared taxa. The occurrence of some uncommon taxa has also been discussed. The benthic mollusc assemblages, although sampled in Ionian Sea, showed a clear western species composition, in accordance with literature placing east of the Strait the boundary line between western and eastern Mediterranean eco-regions. Opposite, occasional records of six mesopelagic species, which included the first record for this area of *Atlanta helicinoidea*, were linked to the local upwelling of Levantine Intermediate Waters.

KEY WORDS Biodiversity; benthos; molluscs; Mediterranean; coastal environment.

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INTRODUCTION

The Strait of Messina, long recognized as a threatened hotspot of biodiversity (Pintner, 1909), is still far from being exhaustively explored, as suggested by the recent revision of "opisthobranch" fauna of transitional waters (Vitale et al., 2016) and by new mollusc species having in the Strait their locus typicus, which notably increased the number of 827 mollusc species assessed for such biogeographic sector (http://www.sibm.it/CHECKLIST/menu%20checklist%20I.htm). Most recent mollusc species included, for example, *Fusinus dimassai* Buzzurro et Russo, 2007; *Tricolia landinii* Bogi et Campani, 2007; *Gibberula cristinae* Tisselli, Agamennone et Giunchi, 2009; *Xylodiscula wareni* Bogi et Bartolini, 2008; *Raphitoma spadiana* Pusateri et Giannuzzi-Savelli, 2012; *Raphitoma smriglioi* Pusateri et Giannuzzi-Savelli, 2013; *Fusinus ventimigliae* Russo et Renda in Russo, 2013; *Granulina lapernai* Smriglio et Mariottini, 2013; *Setia homerica* Romani et Scuderi, 2015; *Skenea giemellorum* Romani, Bogi et Bartolini, 2015; *Vetulonia giacobbei* Renda et Micali, 2016; *Granulina zanclea* Bogi, Boyer, Renda et Giacobbe, 2016; *Jujubinus errinae* Smriglio, Mariottini et Giacobbe, 2016; *Alvania scuderii* Villari, 2017. Such a wealth of diversity, nevertheless, represents the sum of numerous disjoined and often occasional reports throughout at least two centuries from Philippi (1836–1844) and does not take into account the environmental changes that have occurred in the meantime. This is to say that

the baselines required for measuring the local effects of the incoming global changes are almost lacking. A review of the whole mollusc diversity is unachievable in the short time due to the extreme complexity of the Strait of Messina ecosystem, but at least some vulnerable environments should be investigated as a priority. The Capo d'Armi cliff, in our opinion, represents one of these priorities, due to the lack of previous investigations, and the key position at the south entrance of the Strait, as well as evident signals of ecosystem decline forecasting a rapid and significant loss of biodiversity.

In this paper, living molluscs contextually sampled from the Capo d'Armi photophilic zone are reported, as a first account of the local mollusc biodiversity. The aim of the study is to provide a baseline for monitoring changes in benthic biodiversity of such crucial area, whose depletion might already be advanced.

MATERIAL AND METHODS

Study area

Capo d'Armi (Fig. 1), the Greek-Roman "Leucopetra", represents the southeastern limit of the Strait of Messina. The backdrops have been recognized as sites of Community importance since 2000 (SIC code IT9350140), with a high degree of vulnerability due to the urbanization. In this area, the continental shelf is lacking, so that the rocky cliff is directly connected to the continental slope, which rapidly overcomes the 1000 meters deep. The local hydrology, since it is directly influenced by the tidal regime and related uphill to the Strait of Messina, is responsible of high levels of plankton primary production (Azzaro et al., 2007).

Sampling plan included three sites, about 200 meters away from each other. In each site, two bathymetric levels (4–6 and 12–16 meters deep) were sampled, each performed by three replicates about 20 meters away from each other. Seasonality was evaluated by replicates carried out in Autumn (I time) and Spring (II time). The samples were collected by scraping 30x30 cm surface of rocky substrate, separately gathered in 0.1 mm mesh sampling-nets, and stored in ethanol 75%. In laboratory, macrofauna was sorted under stereomicroscope and the specimens were determined at species level, as far as possible. Specimens were counted separately for each replicate, but taxa abundance per sample was evaluated by the three pooled replicates.

Most relevant species have been photographed by means of USB DCM130 digital camera mounted on a binocular microscope. The photos were then processed with Photoshop software.

Nomenclature followed WoRMS (http://www.marinespecies.org/), updated at 2017-12-24.

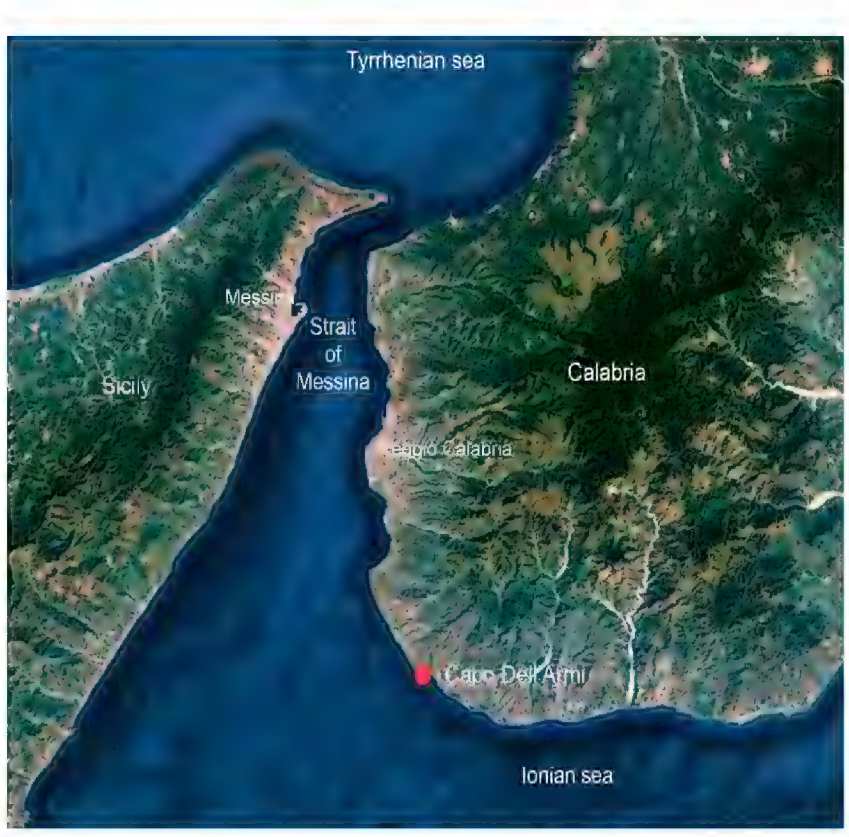

Figure 1. Study area: Capo d'Armi, Strait of Messina.

RESULTS

Benthic species

A total of 2414 specimens belonging to 133 benthic taxa have been recorded, and their taxonomic position is summarized in Table 1. The species were almost equally distributed between the two seasons, weakly declining from spring to autumn (98 and 91 species, respectively), although specimen abundance increased (1014 and 1360 individuals, respectively). A total of 56 taxa were shared, whilst 42 taxa were exclusively recorded in spring and 35 in autumn. The not shared taxa were generally represented by few specimens, reaching a maximum of 6 individuals for both *Gouldia minima* (Montagu, 1803) and *Tritia incrassata* (Strøm, 1768), recorded in spring. The number of specimen for species was generally low, except for a half

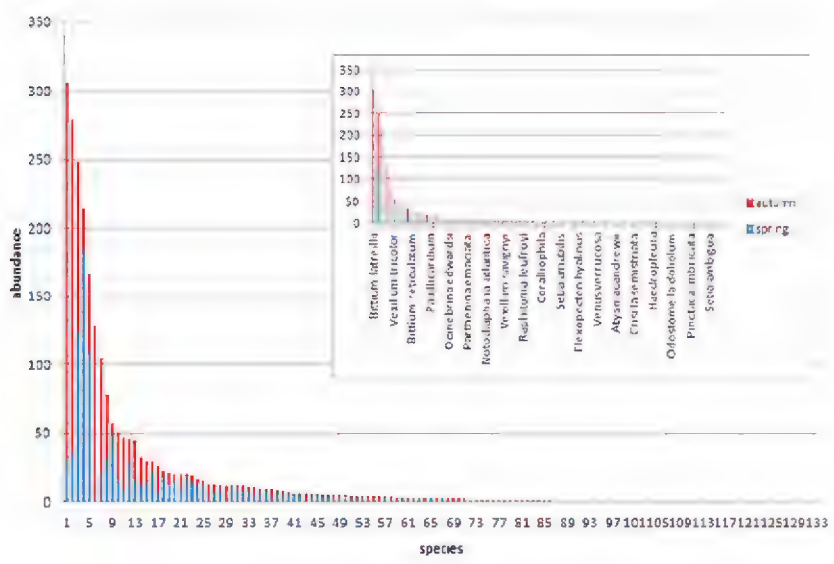

Figure 2. Rank ordination of species (decreasing number of specimens for species) and detail of the 22 most abundant species (> 20 specimens), according to their spring (blue) and autumn (red) abundance.

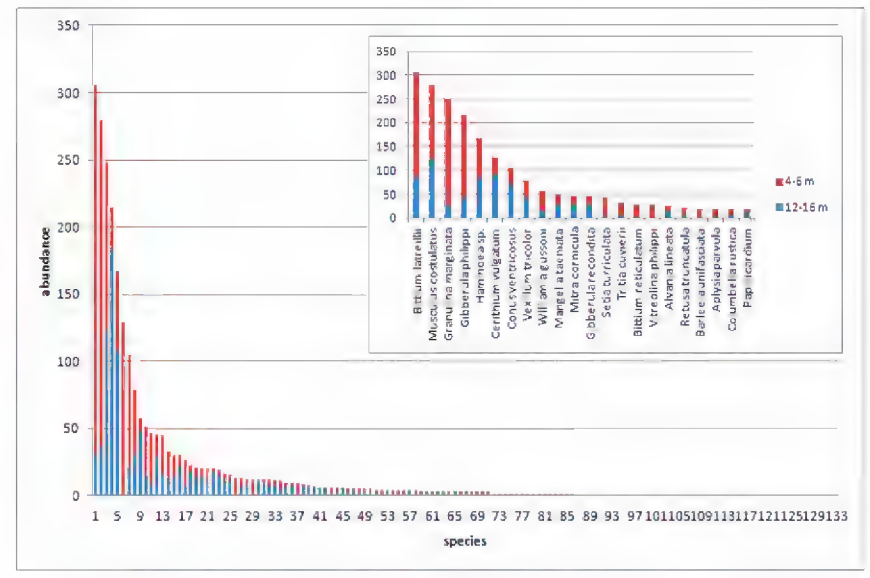

Figure 3. Rank ordination of species (decreasing number of specimens for species) and detail of the 22 most abundant species (> 20 specimens), according to the lower (red) and deeper (blue) bathymetric levels.

dozen of taxa which together accounted for 50% of total (Fig. 2). Within such restricted group of species, the two most abundant ones, *Bittium latreillii* (Payraudeau, 1826) (306 specimens) and *Musculus costulatus* (Risso, 1826) (279 specimens) dominated the autumnal assemblage, followed by *Granulina marginata* (Bivona, 1832) (248 specimens) who was equally distributed between the two seasons. On the other hand, the 4th and 5th ranked species, i.e. *Gibberula philippi* (Monterosato, 1878), 215 specimens, and *Haminoea* sp., (167 specimens), prevailed in autumn. The 129 specimens of *Cerithium vulgatum* Bruguière, 1792 were recorded in spring except for a single one found in autumn.

Bathymetric distribution (Fig. 3) showed scanty differences between the 4–6 and 12–16 meters deep levels, which shared 59 species, including all the 22 most abundant ones. Other 30 species were recorded only at 4–6 meters deep vs the 53 exclusively found at 14–16 meters. Although most of the not shared species (47) provided only a specimen, at least *Rissoa variabilis* (Megerle von Mühlfeld, 1824) and *Tricolia pullus* (Linnaeus, 1758) (12 individuals of both species at 14–16 meters deep) reached almost high concentrations. Within the group of most abundant species, *B. latreillii*, *G. marginata* and *G. philippi* best characterized the shallower depth, *M. costulatus*, *Haminoea* sp. and *Pusia tricolor* (Gmelin, 1791) were almost equally distributed between the two levels, whilst *C. vulgatum* and *Conus ventricosus* Gmelin, 1791 were most abundant at a deeper level.

The most abundant species, as expected, are well known and widely distributed in the Mediterranean Sea. The marginellid *Gibberula recondita* Monterosato, 1884 nevertheless, is a typical western species, unknown in the eastern Mediterranean basins (Gofas, 1990), while *G. marginata* and *G. philippi* (Fig. 4), which are the most tied to the western basins (Gofas, 1990; Boyer et al., 2002), have been sporadically reported in the eastern areas, but without confirmation by pictures of shells and observations on the mollusc chromatic patterns. The same *G. philippi* in the Strait of Messina might be represented by a not yet investigated species complex.

Figure 4. *Gibberula philippi* from Capo d'Armi, Strait of Messina.

SYSTEMATICS

POLYPLACOPHORA

CALLOCHITONIDAE Plate, 1901
Callochiton calcatus Dell'Angelo et Palazzi, 1994

CHITONIDAE Rafinesque, 1815
Chiton (*Rhyssoplax*) *olivaceus* Spengler, 1797

ACANTHOCHITONIDAE Simroth, 1894
Acanthochitona fascicularis (Linnaeus, 1767)

GASTROPODA

SCISSURELLIDAE Gray, 1847
Scissurella costata d'Orbigny, 1824

TROCHIDAE Rafinesque, 1815
Clanculus cruciatus (Linnaeus, 1758)
Jujubinus striatus (Linnaeus, 1758)

CALLIOSTOMATIDAE Thiele, 1924 (1847)
Caliostoma laugieri (Payraudeau, 1826)
Calliostoma sp.

PHASIANELLIDAE Swainson, 1840
Tricolia pullus (Linnaeus, 1758)
Tricolia tenuis (Michaud, 1829)

CERITHIIDAE Fleming, 1822
Bittium latreillii (Payraudeau, 1826)
Bittium reticulatum (da Costa, 1778)
Bittium submamillatum (De Rayneval et Ponz, 1854)
Cerithium renovatum Monterosato, 1884
Cerithium vulgatum vulgatum Bruguiere, 1792

TRIPHORIDAE Gray, 1847
Strobiligera brychia (Bouchet et Guillemo, 1978)
Monophorus sp.

CERITHIOPSIDAE H. Adams et A. Adams, 1853
Cerithiopsis buzzurroi (Cecalupo et Robba, 2010)

EULIMIDAE Philippi, 1853
Melanella polita (Linnaeus, 1758)
Vitreolina incurva (B.D.D., 1883)
Vitreolina philippi (de Rayneval et Ponzi, 1854)

RISSOOIDAE Gray, 1847
Rissoa guerini Recluz, 1843
Rissoa lia (Monterosato, 1884)
Rissoa similis Scacchi, 1836
Rissoa variabilis (Von Muhelfeldt, 1824)
Alvania cancellata (da Costa, 1778)
Alvania cimex (Linnaeus, 1758)
Alvania discors (Allan, 1818)
Alvania hispidula (Monterosato, 1884)
Alvania lanciae (Calcara, 1845)
Alvania lineata Risso, 1826
Alvania cfr *lineata* Risso, 1826
Pusillina lineolata (Michaud, 1832)
Pusillina marginata (Michaud, 1830)
Pusillina philippi (Aradas et Maggiore, 1844)
Setia amabilis (Locard, 1886)
Setia ambigua (Brugnone, 1873)
Setia homerica Romani et Scuderi, 2015
Setia turriculata Monterosato, 1884

RISSOINIDAE Stimpson, 1865
Rissoina bruguieri (Payraudeau, 1826)

BARLEEIDAE Gray, 1857
Barleeia unifasciata (Montagu, 1803)

CAECIDAE Gray, 1850
Caecum subannulatum de Folin, 1870

CALYPTRAEIDAE Lamarck, 1809
Crepidula moulinsii Michaud, 1829
Calyptraea chinensis (Linnaeus, 1758)

NATICIDAE Guilding, 1834
Natica sp.
Notocochlis dillwynii Payraudeau, 1826

ATLANTIDAE Rang, 1829
Atlanta helicinoidea J.E. Gray, 1850
Atlanta peronii Lesueur, 1817

MURICIDAE Rafinesque, 1815
Hexaplex trunculus trunculus (Linnaeus, 1758)
Ocinebrina aciculata (Lamarck, 1822)
Ocinebrina edwarsii (Payraudeau, 1826)
Muricopsis cristata (Brocchi, 1814)
Coralliophila meyendorffii (Calcara, 1845)

MARGINELLIDAE Fleming, 1828
Granulina marginata (Bivona, 1832)

CYSTISCIDAE Stimpson, 1865
Gibberula miliaria (Linnaeus, 1758)
Gibberula philippi (Monterosato, 1878)
Gibberula cfr *philippi* (Monterosato, 1878)
Gibberula recondita Monterosato, 1844

MITRIDAE Swainson, 1829
Mitra cornicula (Linnaeus, 1758)

COSTELLARIIDAE MacDonald, 1860
Pusia savignyi (Payraudeau, 1826)
Pusia tricolor (Gmelin, 1790)

BUCCINIDAE Rafinesque, 1815
Euthria cornea Linnaeus, 1758
Chauvetia affinis (Monterosato, 1889)
Enginella leucozona (Philippi, 1844)
Aplus dorbignyi (Payraudeau, 1826)

NASSARIIDAE Iredale, 1916 (1835)
Tritia cuvierii (Payraudeau, 1826)
Tritia incrassata (Stroem, 1768)

COLUMBELLIDAE Swainson, 1840
Columbella rustica (Linnaeus, 1758)
Mitrella scripta (Linnaeus, 1758)

FASCIOLARIIDAE Gray, 1853
Fusinus dimassai Buzzurro et Russo, 2007
Fusinus pulchellus (Philippi, 1844)

CLATHURELLIDAE H. Adams et A. Adams, 1858
Clathromangelia granum (Philippi, 1844)

CONIDAE Fleming, 1822
Conus ventricosus Gmelin, 1791

RAPHITOMIDAE Bellardi, 1875
Raphitoma bicolor (Risso, 1826)
Raphitoma contigua (Monterosato, 1884)
Raphitoma laviae (Philippi, 1844)
Raphitoma leufroyi (Michaud, 1828)
Raphitoma linearis (Montagu, 1803)

MANGELIIDAE P. Fischer, 1883
Mangelia multilineolata (Deshayes, 1835)
Mangelia taeniata (Deshayes, 1835)

PYRAMIDELLIDAE J.E. Gray, 1840
Parthenina decussata (Montagu, 1803)
Parthenina emaciata (Brusina, 1866)
Parthenina interstincta (J. Adams, 1797)
Parthenina sp.
Megastomia conoidea (Brocchi, 1814)
Odostomia sp.
Odostomella bicincta (Tiberi, 1868)
Odostomella doliolum (Philippi, 1844)
Liostomia cfr *hansgei* Warén, 1991
Turbonilla gradata Bucquoy, Dautzenberg et Dollfus, 1883
Turbonilla pusilla (Philippi, 1844)
Turbonilla cfr *sinuosa* (Jeffreys, 1884)
Eulimella acicula (Philippi, 1836)

BULLIDAE Gray, 1827
Bulla striata Bruguiere, 1792

RETUSIDAE Thiele, 1925
Retusa mammillata (Philippi, 1836)
Retusa minutissima (Monterosato, 1878)
Retusa truncatula (Bruguiere, 1792)

NOTODIAPHANIDAE Thiele, 1931
Notodiaphana atlantica Ortea, Moro et Espinosa, 2013

HAMINOEIDAE Pilsbry, 1895
Haminoea sp.
Atys macandrewii Smith E.A., 1872

PHILINIDAE Gray, 1850 (1815)
Philine catena (Montagu, 1803)

CRESEIDAE Rampal, 1973
Styliola subula (Quoy et Gaimard, 1827)

LIMACINIDAE Gray, 1840
Heliconoides inflatus (d'Orbigny, 1834)
Limacina trochiformis (d'Orbigny, 1834)

PERACLIDAE Tesch, 1913
Peracle reticulata (d'Orbigny, 1834)

VOLVATELLIDAE Pilsbry, 1895
Ascobulla fragilis (Jeffreys, 1856)

PLEUROBRANCHIDAE Gray, 1827
Berthella plumula (Montagu, 1803)

APLYSIIDAE Lamarck, 1809
Aplysia parvula Mörch, 1863
Petalifera petalifera (Rang, 1828)

SIPHONARIIDAE Gray, 1827
Williamia gussoni (Costa O. G., 1829)

BIVALVIA

ARCIDAE Lamarck, 1809
Arca noae Linnaeus, 1758

NOETIIDAE Stewart, 1930
Striarca lactea (Linnaeus, 1758)

MYTILIDAE Rafinesque, 1815
Modiolula phaseolina (Philippi, 1844)
Musculus costulatus (Risso, 1826)

PINNIDAE Leach, 1819
Pinna nobilis Linnaeus, 1758

PTERIIDAE Gray, 1847 (1820)
Pinctada imbricata radiata (Leach, 1814)

PECTINIDAE Rafinesque, 1815
Flexopecten hyalinus (Poli, 1795)

LIMIDAE Rafinesque, 1815
Lima sp.
Limaria hians (Gmelin, 1791)
Limaria cfr *loscombi* (Sowerby G.B.I, 1823)

LUCINIDAE Fleming, 1828
Ctena decussata (Costa O.G., 1829)

CHAMIDAE Lamarck, 1809
Chama gryphoides (Linnaeus, 1758)

CARDITIDAE Férussac, 1822
Cardita calyculata (Linnaeus, 1758)

CARDIIDAE Lamarck, 1809
Parvicardium scriptum (Bucquoy, Dautzenberg et Dollfus, 1892)
Parvicardium sp.
Papillicardium papillosum (Poli, 1796)

TELLINIDAE Blainville, 1814
Tellina sp.

SEMELIDAE Stoliczka, 1870 (1825)
Abra alba (Wood W., 1802)

VENERIDAE Rafinesque, 1815
Venus verrucosa Linnaeus, 1758
Gouldia minima (Montagu, 1803)
Lajonkairia lajonkairii (Payraudeau, 1826)

HIATELLIDAE Gray, 1824
Hiatella arctica (Linnaeus, 1767)

Table 1. Molluscs from Capo d'Armi, Strait of Messina: taxonomic position.

Figure 5. *Aplysia parvula* from Capo d'Armi, Strait of Messina.

Less abundant species, whose occurrence might be considered negligible in quantitative terms, included some taxa on which it is worth to dwell. The rayed pearl oyster *Pinctada imbricata radiata* (Leach, 1814), for example, is an "hystorical" Lessepsian migrant that reached the Gulf of Gabes, in central Mediterranean, at the end of the 19th century (Bouchon-Brandely & Berthoule, 1891) and only fifty years later the islands in the south of Sicily (Bombace, 1967; Sabelli, 1969); it took the species a further half-century to reach the Strait of Messina where it was sporadically recorded during 2000–2001 and regularly found since 2007 (Crocetta et al., 2009; Giacobbe et al., 2010). The present record (first one in the framework of a quantitative sampling plan), may be considered a last evidence of *P. imbricata radiata* settlement in the Strait of Messina area.

The Caraibic Sea hare, *Aplysia parvula* (Fig. 5), that we report for the first time in the Strait of Messina, despite its western Atlantic origin, in Mediterranean Sea has been first recorded in the eastern basin, from Turkish waters (Swennen, 1961). Numerous but often unconfirmed records affected both Atlantic and Mediterranean coasts of Spain and Balearic Islands (Terlizzi et al., 2005; Koukouras, 2010; Scuderi & Terlizzi, 2012). Such peculiar Amphi-Atlantic and Mediterranean distribution, however, may suggests a cryptogenic status of the Mediterranean populations, which might belong to a different species than the west Atlantic topotypical ones (Zenetos et al., 2010). A very similar case concerned *Notodiaphana atlantica* Ortea, Moro et Espinosa, 2013 (Fig. 6), a shelled Heterobranchia that has been described from specimens collected between Bahamas and Cuba, and shortly after reported from several Mediterranean localities such as Djerba (Tunisia), Cabo Negro (Morocco), Messina and Augusta (Sicily), and Strait of Sicily (Micali, 2014). Here again, the doubt that Atlantic and Mediterranean populations might belong to genetically distinct species, is legitimized by the disjoined Amphi-Atlantic distribution. Another shelled Heterobranchia, *Atys macandrewi* E.A. Smith, 1872 (Fig. 7), described from Lanzarote (Canary Islands), has been cited in recent years for several Mediterranean localities as Malta, Messina, Tel Aviv (Cachia & Mifsud, 2007), Cyprus (Delongueville & Scaillet, 2010), Malaga and Motril from Spagna, Pantelleria and Lampedusa from Italy, and Elafonissi from Greece (Micali et al., 2016). Such records identify an area which includes both Mauritanian and Mediterranean provinces, although it is limited to medium-low latitudes.

Both the latter two species, already reported for the Strait of Messina (Cachia & Misfud, 2007; Micali, 2014), had robust confirmation in the present quantitative sampling.

The Sacoglossa *Ascobulla fragilis* (Jeffreys, 1856) (Fig. 8), whose prevalent western distribution includes the Italian Tyrrhenian coasts according to the SIBM check-list of Italian marine species (http://www.sibm.it/CHECKLIST/menu%20checklist%20I.htm), before now has not been reported from the Strait of Messina. However, some uncertainties concern the effective areal of this species, known from Alboran and other Mediterranean coasts of Spain (Cervera et al., 2004) but dubiously reported in WoRMS (http://www.marinespecies.org/), from other western areas, whilst it was ascertained from eastern Mediterranean, notably Greece (Koulouri et al., 2006). Such disjoined distribution, if not refuted by future reports in central Mediterranean, might involve some genetic divergence between the western and eastern populations. In this regard, the present first record in the Strait of *A. fragilis*, is not conclusive, since it might represent a link between two apparently disjoined populations, or it could be contextualized in the well known "Atlantic affinity" (Bianchi et al., 2012) of the ecosystem in the Strait of Messina.

Planktonic species

Besides benthic species, the examined samples provided 46 living specimens of six planktonic taxa, accidentally trapped by algal covering; such species have been here reported as a contribution to the knowledge of the complessive mollusc diversity in Capo d'Armi area. They included the Littorinimorpha *Atlanta peronii* Lesueur, 1817 and *A. helicinoidea* J.E. Gray, 1850, and the Thecosomata *Heliconoides inflatus* (d'Orbigny, 1834), *Limacina trochiformis* (d'Orbigny, 1834), *Peracle reticulata* (d'Orbigny, 1834) and *Styliola subula* (Quoy et Gaimard, 1827). Both the *Atlanta* Lesueur, 1817 species have a circumtropical distribution that includes the Mediterranean Sea, but while *A. peronii* is common in the whole Mediterranean, *A. helicinoidea* exclusivelly occurs in the eastern basins (Wall-Palmer et al., 2016). This latter taxon, that has been dubiously cited in the most recent check-list for the Italian Seas (http://www.sibm.it/CHECKLIST/menu%20 checklist%20I.htm), has not been previous reported in literature for the Strait of Messina area (Guglielmo et al., 1995).

The Thecosomata *H. inflatus*, belonging to a species complex which includes Atlanto-Mediterranean, Indo-Pacific, South Eastern Atlantic and North Indian entities, in Mediterranean is known from the western basins. *Limacina trochiformis* is abundant in the South Western and Eastern areas (Rampal, 2017), similarly to *S. subula* and to the epibathyal *P. reticulata*, which shows a disjoined distribution in Alboran sea and Eastern basin (Rampal, 1975, 2011).

Figure 6. *Notodiaphana atlantica* from Capo d'Armi, Strait of Messina.

CONCLUSIONS

The present report provides a first contribution to the mollusc diversity in a poorly investigated area, although the latter is full of interest in the contest of Mediterranean biogeography. It also improves our knowledge on the Strait of Messina ecosystem, of which has been recognized the absolute peculiarity. Such data, unfortunately, described an environment whose decline was meanwhile highlighted by the incipient rarefaction of the algal canopy, preluding to the barren-dom-inated present seascape. Benthic mollusc assemblages, although sampled in Ionian Sea, showed a clear western species composition, confirming previous literature that placed east of the Strait the biogeographic boundary line between western and eastern Mediterranean eco-regions (Bianchi, 2007 and literature herein cited). Pelagic molluscs, by contrast, showed a more marked eastern imprint, in agreement with Guglielmo et al. (1995) highlighting the role of local upwelling in the occurrence of pelagic assemblages tied to the Levantine Intermediate Waters, LIW.

Figure 7. *Atys macandrewi* from Capo d'Armi, Strait of Messina.

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Figure 8. *Ascobulla fragilis* from Capo d'Armi, Strait of Messina.

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Updated status of European Lanner Falcon, *Falco biarmicus feldeggii* (Schlegel, 1843) (Aves Falconiformes): a taxon on the verge of extinction, with brief comments on the North African Lanner, *F. biarmicus erlangeri* (Kleinschimdt, 1901)

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ABSTRACT Information on the breeding population size of European Lanner Falcon, *Falco biarmicus feldeggii* Schlegel, 1843 (Aves Falconiformes), up to the breeding season 2017 are here given, showing how this peculiar and distinctive taxon is now threatened. A brief overview of the most relevant past and recent information available for the main breeding strongholds is reported, with a more circumstanced status for Turkey and other countries for which the data so far published were either out of date or misleading. The general figure is at no more than ca. 200 breeding pairs worldwide, with slightly more known nesting territories so far remaining. Some comments for the North African subspecies *F. biarmicus erlangeri* (Schlegel, 1843) are also concisely reported, showing how also this taxon is steadily declining.

KEY WORDS Fast decline; *feldeggii* Lanner; world population size.

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INTRODUCTION

The Lanner Falcon, *Falco biarmicus* Temminck 1825 (Aves Falconiformes), is a widely distributed raptor (Figs. 1–5), with various subspecies across Southern and Eastern Europe, the Caucasus, the Middle East and extensively in Africa (Leonardi, 2015). All its subspecies have good population sizes, while the unique and very distinctive subsp. *feldeggii* (Schlegel, 1843) is rather localized (Cramp & Simmons, 1980; Massa et al., 1991; Krueger et al., 1996; Corso 2000, 2001; Gustin et al., 2002; Andreotti & Leonardi, 2007; Allavena et al., 2015; Leonardi, 2015; Di Vittorio et al., 2017). In the 1800s and early 1900s, *F. biarmicus feldeggii* was still common, chiefly in Italy (Arrigoni degli Oddi, 1929; Martorelli, 1911; Mebs, 1959; Toschi, 1969). From January 1919 to Feb-ruary 1921, more than 200 specimens of *F. biarmicus feldeggii* (most of them juveniles, but also adults) were collected in Puglia, Italy, alone (and sent to museums all over Italy, Europe and elsewhere in the world) (Arrigoni degli Oddi, 1929; Foschi et al., 1996; pers. obs.). Recent estimates of the world population of *F. biarmicus feldeggii* were of a maximum of ca. 400–900 pairs, including 123–172 breeding pairs in Italy (65+ in Sicily, the rest on the mainland) (Allavena et al., 2015; Leonardi, 2015). However, even the most updated mono- graphies on Lanner, such as Allavena et al. (2015) and Leonardi (2015) for some countries report old and/or unverified data, such as that from Turkey and Greece (Kirwan et al., 2008a, b; Kirwan & Yoğurtcuoğlu pers. com.; pers. obs.). Indeed, more likely estimates from the core distribution range are nowadays much lower and therefore the status of *F. biarmicus feldeggii* need to be

revised. This short note updates the figure of the breeding population of this endangered taxon. As clearly shown here, *F. biarmicus feldeggii* is sadly on the verge of extinction. A figure for the whole *F. biarmicus feldeggii* breeding population is reported, with a discussion for the most relevant breeding areas. Comments about the possible negative population trend of the North African taxon, *F. biarmicus erlangeri* (Kleinschimdt, 1901), are also briefly discussed.

MATERIAL AND METHODS

This short note is the fruit of twenty years of intense personal field observations through most of the *F. biarmicus feldeggii* breeding range in Italy (Corso et al., 2017). A sample area of the core range in Turkey and Caucasus was also visited during the years 2009–2017 (combined). Sample areas of the known breeding range of *F. biarmicus erlangeri* in Tunisia and Morocco were visited during the years 1999–2014 and 2001–2016 respectively. Furthermore, potential suitable habitat in areas where the species could potentially breed were also visited. The breeding area covered (Central to Southern Tunisia, Central to Southern Morocco) was visited annually during the same period (January to the end of March-early April). A great part of the data discussed concisely here, however, was also gathered through correspondence with ornithologists from the GTR (Gruppo Tutela Rapaci), HOS (Hellenistic Ornithological Society), BRC (Batumi Raptors Count) and a large number of ornithologists who kindly shared their observations and studies (see acknowledgements). All the most relevant papers dealing with the Lanner Falcon of the subspecies *F. biarmicus feldeggii* and *F. biarmicus erlageri* were thoroughly studied in order to acquire data that is as detailed and updated as possible. A partial list of the numerous scientific papers read is reported under many references.

RESULTS

Details regarding the breeding pairs of *F. biarmicus feldeggii* from the whole distribution range are given in Table1. Figures reported in this table show the most up-to-date information mentioned by the major works on the Lanner Falcon published in recent years. The total world breeding population of *F. biarmicus feldeggii* can be roughly estimated at 261–462 pairs for Andreotti & Leonardi (2007), 340–460 (max. range 572–960) for Leonardi (2015) and 408–815 for Allavena et al. (2015). These works, report unverified and, sometimes exaggerated estimates for certain countries, where data are either deficient or based upon incorrect statements from old literature. Indeed, Leonardi (2015) stresses the lack or the low quality of modern data for some breeding areas. The most relevant case is Turkey, while for many Eastern European countries, including Greece, the data still refer back to the 1980s and have never been updated since. The 5th column of Table1 report the known breeding pairs of *F. biarmicus feldeggii* for the year 2017: these could be estimated as 119–171 pairs, with a maximum estimate of 257 nesting territories known. Thereafter, it is reported an overview primarily concerning the countries covering *F. biarmicus feldeggii*'s main core range.

ITALY. Massa et al. (1991), Krueger et al. (1996) and Gustin et al. (2002) estimate the Italian breeding population of *F. biarmicus feldeggii* at about 170–200+ pairs (80–90 of which being found in Sicily). Andreotti & Leonardi (2007) and Andreotti et al. (2008) updated the figure to 140–172 pairs (and 70–80 for Sicily). Leonardi (2015) repeated the same 140–172 pair figure while the number provided by Allavena et al. (2015) in an extensive region by region review provides a lower estimate of 123–152 pairs (and 65 in Sicily). In this work however, some odd data are reported, such as the one from Campania, for example with 3–4 breeding pairs monitored in the past in that region, none of which were actually ever observed at the nest in 2014–2015. Still, 3–4 breeding pairs are reported in the table summarising the Italian population, with the explanation that "*surely some elusive pairs, not monitored, exist in the region*" . Furthermore, in some regions, for example Abruzzo, the same number of breeding pairs from past works is reported (4–6 pairs) whereas in reality the number has already measurably declined since 2011–2012, as Corso (2013) had already reported the regional populations at 2–3 pairs (reduced to 1–2 in 2017; Antonucci, Carafa, Cappelli and Pulvirenti pers. com.; pers. obs.). In 2015–2017, the dramatic decline was finally acknowledged by Italian orni-

Figure 1. World distribution range of Lanner Falcon *Falco biarmicus feldeggii* (Schlegel, 1843) as previously reported in recent works. The main stronghold, after this study - 1) blue squares population which strongly declined or for which the figure need to be updated; 2) blue circle, population almost eradicated; 3) green squares, mostly Saker Falcon *Falco cherrug* (Gray, 1834) found breeding in these areas in last decade; 4) red square, considered the Turkish stronghold, in recent years no or very few lanners observed in this area.

COUNTRY	BREEDING PAIRS Andreotti & Leonardi (2007)	BREEDING PAIRS Leonardi (2015)	BREEDING PAIRS Allavena et al. (2015)	Updated estimate year 2017	TREND
Italy	140-172	140-172	123-152	60-80 (106)	Negative
Turkey	50-200	100-150 (300-600)	200-500	20-30 (50)	Negative
Macedonia	>5	25-35	25-35	15-20 (30)	Stable?
Greece	36-55	38-53	45-75	20 (35-40)	Negative
Montenegro	2-5	8-12	2-5	1-5	Negative
Georgia	5 (tot. combined with Armenia and Azerbaijan)	1-2	1-3	1-2	Negative
Bosnia-Herzegovina	>5	12	1-5	1-2	Negative
Croatia	5-10	5 (10-20)	1-4	1-4	Negative
Serbia	3-5	5-10	0-1	0-1	Negative
Kosovo	?	2-3	0-2	0-1	Negative
Bulgaria	>10	2-3	0-3	0-1	?
Armenia	Rif Georgia	1-2	5-10	? (5)	?
Azerbaijan	Rif Georgia	1	5-20	? (5-10)	?
Tot.	261-462	340-460 (572-960)	408-815	119-171 (**257**)	**Negative**

Table 1. Numbers of estimated breeding pairs of Lanner Falcon *Falco biarmicus feldeggii* Schlegel, 1843 in the whole of its known distribution range according to the latest works on this taxon, compared to number of breeding pairs estimated in 2017. In brackets, the maximum estimated number of nesting territories.

thologists monitoring the species, with specific papers showing a decline at regional or national level for Regions such as Tuscany (Pezzo et al., 2016), Lazio (Brunelli & Sarrocco, 2017; Borlenghi et al., 2017), Abruzzo (Corso, 2013), Molise and Central and Southern Italy (De Lisio et al., 2015; De Rosa et al., 2017). For Sicily, in recent years, several works provide contradictory figures. To quote just some examples, Sarà (2008) gives a total breeding population for Italy of 100–140 pairs and, amazingly, 120–125 pairs for Sicily alone. Similarly, Sarà (2014) reports 122 breeding territories during 2000–2009, 92 of which were regularly occupied. This data however, does not correspond to monitoring research undertaken by various Sicilian ornithologists (Di Vittorio and Ciaccio pers. com.; GTR database; pers. obs.). On the other hand, Di Vittorio et al. (2017) clearly demonstrate a negative trend in both the number of breeding pairs in Sicily, from 70–90 in the 1980s and 1990s to no more than 55–60 by 2016, and the productivity which has also diminished in the last 20 years. A further decline was recorded in Sicily in 2017 with an estimate of 56 nesting territories (but only 30 breeding pairs) and a very low rate of substitution of adults at the nest, showing a demography-related problem and high mortality (Di Vittorio, Ciaccio, Scuderi, Merlino pers. com., GTR; pers. obs.). Given that Sicily was always the main stronghold of *F. biarmicus feldeggii*, this decline is particular worrying (Di Vittorio et al., 2015, 2017; pers. obs.). The general figure for the whole of Italy in the years 2016 and 2017 is of around 60–80 remaining breeding pairs, with a maximum count of 106 nesting territories holding pairs (not necessarily referring to breeding adults).

TURKEY. First breeding records reported by Kumerloeve & Niethammer (1935). Kumerloeve (1961, 1970, 1972) mention the species, considering Lanner a well distributed breeding species across the country though with scattered pairs. Beaman & Porter (1985) report "*status uncertain, probably a scarce breeding species*". Kirwan (1997) did not find any specimens of Lanner preserved at the Robert's College collection, at Bebek (Istanbul). Kirwan (1995), Kirwan & Martins (1994), and Kirwan et al. (2003, 2008a) report only a few confirmed records of the species around the country. Meyburg & Meyburg (1987) estimate the Turkish population of Lanner at only 20 breeding pairs, a figure also repeated by Grubac (1996). Kirwan et al. (2008b) mention very few well documented breeding records, with only a few well-known and studied nesting sites, reporting that the "*breeding status and distribution remain poorly understood and badly need further clarification*". Allavena et al. (2015) and Leonardi (2015), on the contrary, mention, respectively, 200–500 and 100–150 pairs, both with an estimate of maximum 300–600 pairs. According to literature, the core breeding range should be found in Eastern Turkey, around the Van district/Eastern Anatolia and the Caucasus-Pontic Alps areas-Black Sea coastlands (Kirwan et al., 2008b; Leonardi, 2015). During the years 2011–2015, personal annual trips in late Spring-early Summer to these areas, did not produce any observation of Lanners, while a few Saker Falcons (*F. cherrug* Gray, 1834) were observed, as well as a few pale Peregrine Falcons (*F. peregrinus* Tunstall, 1771). Already Kasparek (1992) mentioned the possibility that many of the Turkish records of Lanner could actually refers to misidentified Saker or even Eleonora's Falcon (*F. eleonorae* Gené, 1839), a possibility also repeated by Kirwan et al. (2008b). It is surely of interest in this context that Dixon et al. (2009) found most breeding pairs of Saker, during the years 2000–2008, in an area very much overlapping with the allegedly main distribution range of Lanner in Turkey. Turan (2005), during a raptor survey conducted in 2001–2002 across the country, reported only 2–5 records for Lanner (and Saker as well). Shurulinkov et al. (2008) reported only two adult birds observed in Eastern Turkey in 2005 and 2007 in the Agri and Sivas districts. Kirwan (pers.com.), reported that during studies across Turkey, he observed no more than 1 to 5 Lanners annually during decades of research in the country, considering several modern records referring to Lanner Falcon as pertaining to misidentified "Nordic" Peregrines (i.e. *F. calidus* Latham, 1790) and Sakers (as commonly happen in Italy and other countries too). Similarly, Yoğurtcuoğlu (pers.com.) reported only few of confirmed Lanners observed in the last ten years in the whole country. The real level of the breeding population of *feldeggii* in Turkey in recent years is therefore completely unknown. However, according to all the ornithologists contacted and cited, it is most likely estimated at about 20–30 breeding pairs (maximum 50) and by no means even close to the 150–600 pairs

reported by Leonardi (2015) and Allavena et al. (2015).

MACEDONIA. This country apparently holds one of the greatest population known to date, estimated at only 5+ pairs by Gustin et al. (2002) and Andreotti & Leonardi (2007), but reported to be 25–35 breeding pairs by both Allavena et al. (2015) and Leonardi (2015). Up to 2009, Grubač & Velevski (2010) mentioned 14 verified breeding pairs with additional 11 probable nesting sites, reporting an estimate of 25–35 pairs in total. Recent observations in the country by several observers confirm the presence of 15–20 active breeding pairs.

GREECE. *F. biarmicus feldeggii* was mainly distributed in Central and northern Greece, with 36–55 breeding pairs reported in the 1980s (Handrinos & Demetropoulos, 1983; Handrinos & Akriotis, 1997). Gustin et al. (2002) thus report 36–55 breeding pairs, a number repeated in Andreotti & Leonardi (2007). Leonardi (2015) reports 38–53 pairs while Allavena et al. (2015) mention 45–75 pairs. All these data are based on research conducted in the 1980s and 1990s. Recent observations made by local/visiting ornithologists and birders in Greece refer to 20 active nests with a maximum estimate of 35–40 nesting territories. Future research, chiefly in the southern part of the country and all surroundings islands, are advisable.

CAUCASUS (SOUTHERN GEORGIA, SOUTHERN ARMENIA AND AZERBAIJAN). Abuladze et al. (1991) report 5 breeding pairs for the whole Caucasus area. Patrikeev (2004) consider Lanner as extirpated or an extremely rare breeder in Azerbaijan. Adamian & Klem (1999) consider *F. biarmicus feldeggii* a very rare breeding bird found primarily in Western Armenia at lower elevations. Leonardi (2015) report 3–5 pairs in total for Georgia, Armenia and Azerbaijan. On the other hand, Gustin et al. (2002) and Allavena et al. (2015) report a cumulative total of about 11–33 pairs. Abuladze (2012, 2013) report a remaining 1–3 pairs for Georgia. Recent correspondence with several ornithologists active in the area, reported an unknown number of pairs, since the species is considered almost eradicated from the area, with only one or two remaining pairs in Southern Georgia, an unknown population size for Armenia and Azerbaijan, where a possible estimate of, respectively, 5 and 5–10 nesting territories (A. Abuladze, A. Rukhaia and B. Verhelst pers. com.). Vasil Ananian (pers. com.) reports that a confirmed and traditional breeding site is found at the Khosrov Forest State Reserve, where one nest is known since 1961, and breeding birds are observed there regularly. Summer records also exist from Mt Aragats (regularly), Ijevan Range (NE of the country), and Sevan Mountain Range (along the Eastern shore of the Lake Sevan). Adamian & Klem (1999) list other records, but some of them need verifications, e.g. summer records from Meghri area (extreme SE of Armenia) are probably erroneous, because here only the Peregrine breeds there. From personal study of several available photos from these countries and personal field observations, it seems that at least a proportion of the breeding pairs reported and/or Lanners observed in the field may actually refer to pale Saker Falcons (*Falco cherrug*). In this area (increasingly moving further east), some adult Sakers appear very similar to adult (mainly adult female) *F. biarmicus feldeggii*: generally bluish-grey upperparts, very well barred both above and below on flanks/belly, well barred remiges and tail, and rusty head/crown (Forsman, 2016; Corso, 2000, 2001; Corso et al., 2017).

BULGARIA. Gustin et al. (2002) report 10+ pairs, while both Allavena et al. (2015) and Leonardi (2015) mention 1–3 pairs. Nankinov et al. (2004) report a single verified breeding pair, while Golemanski et al. (2011) estimate 4–10 the breeding population for this country. Recent field studies report 0–1 pairs (Najankensko pers. com.), considering the single observations over the country as mostly pertaining to vagrants from nearby regions of Greece and Yugoslavia as already postulated by Boev & Dimitrov (1995). However, during raptor migration surveys in August–October 1979–2003 conducted at Bourgas by Michev et al. (2011), no Lanners were observed. For all the other countries where a few pairs are found, see Table1.

NORTH AFRICA - *Falco biarmicus erlangeri*. Given the long direct field experience gained by me concerning the subspecies erlangeri, I report comments on what I have personally recorded in Morocco and Tunisia. Old information about North Africa in general is provided by Heim de Balsac & Mayaud (1962), where the authors considered the species widespread and abundant in the area, and most common in Morocco. Bergier (1987) reported a rough estimate of around 1000 breeding pairs in

the 1970s and 1980s for Morocco. Similarly, Thévenot et al. (1985) reported about 1000 pairs in the country, while Thévenot et al. (2003) considered the species as, at least modestly decreasing, and therefore with a smaller population size. However, data are highly deficient for the last two decades, and thus its real status and population size/trend are strongly in need of an update (Leonardi, 2015). M. Amezian (pers. com.) is of the same opinion, but following field observations over decades by his colleagues and him, it looks like, the species is definitely exhibiting a rather negative trend. Further studies are therefore necessary to understand the species' health in the main strongholds for *F. biarmicus erlangeri*. For Tunisia, Whitaker (1905) considered Lanners as the commonest large falcon over the country. Both Isenmann et al. (2005) and Leonardi (2015) report and estimate 350–400 breeding pairs for the 1990s and up to the middle of the first decade of the 21st century. However, Grubac (1996) and Meyburg & Meyburg (1987) consider a likely estimate of 200–250 pairs. Recent, updated, in depth research is lacking, and therefore little is known about the real population size and trend of this falcon in Tunisia. During numerous breeding seasons (see Material and Methods), Tunisia and Morocco were regularly visited with the finding of no less than 50 nesting territories (31 Tunisia, 19 Morocco - only 26 of which with actually breeding pairs and both adults at the nest). A stable number of nesting territories was recorded up until 2010, when no less than 10 sites appeared deserted (20%). In the years 2011–2013, only 24 nesting sites in total were apparently still occupied by at least one adult Lanner, and just 20 in 2014–2016 (a decline of 60%). Observing *F. biarmicus erlangeri* in the field in these two countries, outside of known nesting territories, was very easy on the 1990s and early 2000s but became increasingly difficult towards 2016. It would seem, therefore, that a similar negative trend as seen in *F. biarmicus feldeggii*, is also underway in *F. biarmicus erlangeri*, and a future focused study should be quickly organised. As far as the subspecies *tanypterus* Schlegel, 1843 in northeast Africa Arabia, Israel, and Iraq is concerned, not enough data about its population size is available. This subspecies is probably localized and with a discontinuous distribution, although the real figure is still rather unclear, chiefly concerning the situation in Libya and Cyrenaica (Leonardi, 2015; Isenmann et al., 2016). In addition, the subspecies *erlangeri* may be considered a synonym of this taxon and therefore the total breeding population size may actually be considered rather large (Clark, 1999; Forsman, 2015; Corso et al. pers. data). However, further research should be conducted to ascertain the true breeding numbers and trend.

CONCLUSIONS

As a final figure, given the updated estimates mainly from Turkey and Italy, the two main strongholds, the world population of *F. biarmicus feldeggii* up to, and including 2017 can be estimated to be around 119–171 breeding pairs, with a maximum estimate of 257 nesting territories. Of course, the lack of ornithological coverage for a broad part of Turkey, the need for better and more extensive research in Greece, Bulgaria, and Macedonia, surely means that some further breeding pairs may be discovered in the future if greater efforts to obtain better knowledge of the population size of this vanishing taxon were to be undertaken. A better search also needs to be made in Croatia, Serbia, Bosnia and Herzegovina, Armenia, and Azerbaijan, where the real population size is unknown and could be higher than reported here, but where some of the potential breeding pairs may actually refers to pale Saker Falcons. Further studies are needed for Romania, Albania, Cyprus, and Crete. Although without doubt new breeding pairs of feldeggii might still be found indeed, it is evident the decline of these populations across Italy, the main world stronghold for this taxon. The reasons for such a quick decline are several, as theorized by many authors and in many different scientific papers, and they are derived from a range of many different factors (see References). One thing is clear and cannot ever be stressed enough: every possible solution needs to be examined and searched, and every possible action needs to be taken. At the same time, disturbance at the nest must be kept by everyone involved to a minimum (or not at all, for example that caused by bird photographers, but also certain ornithologists), and all environmental associations, together with the European Union, must co-operate to avoid further declines, and to prevent at least some of the most important threat factors.

Figure 2. European Lanner *Falco biarmicus feldegii,* Southern Sicily, Italy, 01.IV.2014 (photo Stefania Merlino). A single adult female, not paired. Figure 3. European Lanner *F. biarmicus feldegii*, Northern Sicily, 23.VII.2017 (photo Giuseppe Rannisi). A moulting adult during post-breeding season. Figure 4. Lanner *F. biarmicus tanypterus*, adult bird, Sde-boker, Northern Israel, June 2016 (photo Lior Kislev). Figure 5. Lanner *F. biarmicus tanypterus*, fresh juvenile, Sde-boker Northern Israel, June 2016 (photo Lior Kislev).

One of these is without any doubt, and by far one of the most relevant, the widespread and increasing practice of falconry, which appears to be completely out of control. As a first step, the simple detention of any *F. biarmicus feldeggii* must be declared illegal and it should not matter if it is said to originate from captive bred stock. It should not be possible to have *F. biarmicus feldeggii* in captivity, whatever its origin. Starting from this point, any illegal commerce could more easily be prevented. Bär (1997) and Dixon et al. (2009) report that falcon trapping in Turkey and Syria was very widespread in the 1970s and even more evident in the 1980s with around 300-600 big falcons being trapped in Turkey and a massive 700-1,200 annually in Syria. Binothman (2016), in a work about falconry in Saudi Arabia, reported that there were approximately 100 trappers active in in Turkey in 2014–2015, illegally trapping falcons (Lanners, Peregrines, Sakers, etc.). Trapping locations are typically located near the Armenian and Georgian borders, and therefore in the alleged strongholds of *F. biarmicus feldeggii* for this country. If this figure were to be confirmed, illegal trapping and falconry are seriously threatening the Turkish *F. biarmicus feldeggii* population and, as a consequence, the entire population of this endangered taxon. The same author (Binothman, 2016) reported a massive capture of wild falcons in North Africa and the Middle East that is hugely worrying for the Lanner population trend as a whole. According to his research, at least 2,544 adult and juvenile Lanner and Peregrine Falcons

were trapped and smuggled to the Middle East in the year 2015. In 2014, there were approximately 4,027 falcons trapped in the Middle East and North Africa (Libya 35.0%, Arabian Gulf 15.5%, Iran 11.1%, Turkey 9.9%, Egypt 8.6%, Yemen 8.1%, Sudan 7.9%, and Jordan 3.4%). In Libya alone, during 2014, 800 lanners were reportedly captured by people working for falconers, with as well as 300 lanners reported as captured in Egypt. There were more than 200 trappers illegally active in Libya in 2014–2015.The allegedly reported figure of captured Lanners (and falcons in general) in the mentioned work is probably, and hopefully, exaggerated, but the number of falcons illegally captured in the whole North Africa and Middle East is certainly massive. Therefore, it should not come as surprise if *F. biarmicus erlangeri*, *F. biarmicus tanypterus* and *F. biarmicus abyssinicus* (Neumann, 1904) (whenever or not all valid taxa) are all quickly declining and could become endangered in the near future.

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Structure of the community associated with the gilthead sea bream *Sparus aurata* Linnaeus, 1758 (Pisces Perciformes Sparidae) of the Algerian east coasts (Jijel, Skikda, Annaba, El-Taraf)

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ABSTRACT

The structure of the community associated with the gilthead sea bream *Sparus aurata* Linnaeus, 1758 (Pisces Perciformes Sparidae) of the Algerian east coasts is studied on the basis of data from the oceanographic campaign "ALDEM 2012" carried out in Algeria. The most characteristic species of the *S. aurata* are determined on the basis of three classification criteria, relative frequency (Fr), density (Dn) and biomass (Dw). These species are 88. Species diversity and evenness are calculated in the coasts of eastern Algeria taking into account the numbers and the weights. Distribution of specific abundance is studied from the models of Motomura, Mac Arthur and Preston. Determination of specific richness, specific diversity, equitability and use of abundance distribution models revealed a young (immature) community with one or more species that tend to dominate in number and weight. A principal component analysis (PCA) was carried out on a matrix of 88 species and 3 variables (Fr, Dn, Dw) in order to separate the species strongly associated with the gilthead sea bream. *Mullus barbatus* is the species most associated with *S. aurata* with a significant presence of *Trachurus trachurus* and *Pagellus acarne* and, to a lesser degree, *Pagellus erythrinus*.

KEY WORDS

Community; *Sparus aurata*; Algerian east coasts; oceanographic campaign.

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INTRODUCTION

The sparids (Pisces Perciformes Sparidae) are abundantly represented on the Algerian coasts (Fischer et al., 1987; Djabali et al., 1993); they are sought-after by fishermen because of their high commercial value which makes them attractive economically. The sparid gilthead sea bream *Sparus aurata* Linnaeus, 1758 is common in the Mediterranean Sea; it is less prevalent in the east and southeast of this sea. It is also present in the eastern Atlantic, from the British islands to Cape Verde islands and Canaries (Fischer et al., 1987).

Gilthead sea bream *S. aurata* Linnaeus, 1758 has an ecological importance, both in Algeria and throughout the Mediterranean. Thus, numerous studies have been devoted to it, notably concerning its biology (Rønnestad et al., 1994; Magoulas et al., 1995; Pita et al., 2002; Stergiou & Karpouzi, 2002; Rossi et al., 2006; Parati et al., 2011).

In Algeria, the gilthead sea bream has been the subject of some studies in lagoon environment

(Chaoui et al., 2005; Chaoui et al., 2006; Chaoui et al., 2009; Chaoui et al., 2012). But in marine environment, apart from the ecological study of Chebel et al. (2014) on old data of the oceanographic campaign of Thalassa (Campillo, 1982), no recent work has been carried out on the gilthead sea bream in the Algerian coasts. Studies of the structure of marine communities have been the subject of much works (Jin & Tang, 1996; Lugendo et al., 2007; Won et al., 2007; Horinouchi et al., 2009).

Our study presents new data on the structure of the community associated with *S. aurata* in the coasts of eastern Algeria, based on the calculation of diversity indices, the application of some ecological models and the study of associated fauna from a principal component analysis (PCA).

MATERIAL AND METHODS

The data used in this study comes from the information gathered during the first campaign of assessment of demersal resources ALDEM 2012 of National Research and Development of Fisheries and Aquaculture Centre (CNRDPA), undertaken by the Grine Belkacem oceanographic boat, during the period from 03 May to 15 June 2012, on the whole Algerian coast. One hundred 100 trawl fisheries were made, from west to east (Ainouche, 2012). In our study area (Algerian east coasts), 33 trawl traits were made.

The fishing gear used is a bottom trawl whose bag mesh is 20 mm. Its horizontal opening is 22 meters and the vertical opening is 1.50 meters; the trawl body is made of polyethylene while the pocket is made of polyamide (Ainouche, 2012). All the specimens captured during the ALDEM 2012 campaign were identified, sorted, counted and weighed. Sex determination was made as soon as possible.

The specific richness S of the community associated with *S. aurata* was determined; it is the number of species found in a community. The calculation of the index of species diversity of Shannon (ISh) (Shannon, 1948) is made from formulas based on the abundance or specific weight.

This index is expressed in bits (binary digits):

$$\mathrm{ISh} = -\Sigma\left(\frac{qi}{Q}\right)\log_2\left(\frac{qi}{Q}\right);$$

with qi: specific abundance and Q: total number of the community considered.

$$\mathrm{ISh} = -\Sigma\left(\frac{wi}{Wt}\right)\log_2\left(\frac{wi}{Wt}\right);$$

with wi: specific weight and Wt: total weight of the community considered.

The equitability or evenness (E) (Pielou, 1966) is defined as the ratio of the real diversity to the maximum diversity ($\log_2$ S):

$$\mathrm{E} = \frac{\mathrm{ISh}}{\log_2 s};$$

The evenness varies from 0 to 1. It tends to be 0 when almost all of the strength is concentrated on a single species. It tends to be 1 when all the species have the same abundance (Daget, 1976).

We studied the distribution of specific abundance and specific weight by models of Motomura (1932), Mac Arthur (1957) and Preston (1962). Statistical tests such as: the correlation coefficient (r) between the observed values (qi and wi) and theoretical values (qth and wth); and the return between the variance of the observed values (V^2(qi) and V^2(wi)) and the variance of the theoretical values (V^2(qth) and V^2(wth) (Daget, 1976), were used in order to assess the degree of adjustment.

The study of associated fauna requires some indices such as:

Relative frequency of the species accompanist:

$$\mathrm{Fr} = \left(\frac{\mathrm{Sp+}}{\mathrm{S+}}\right)100;$$

Density of the species accompanist:

$$\mathrm{Dn} = \frac{\mathrm{qi}}{\mathrm{SS+}};$$

Biomass of the species accompanist:

$$\mathrm{Dw} = \frac{\mathrm{wi}}{\mathrm{SS+}};$$

where, Sp+: number of stations where the species accompanist is present; S+: number of stations where the target species is present; SS+: sum of the areas of S+ stations; qi: specific abundance; wi: specific weight (Hemida, 2005; Harchouche, 2006). These indices (Fr, Dn and Dw) were needed for principal components analysis (PCA).

RESULTS

Specific richness

In total, 88 species belonging to different zoological groups (Table 1) were retained for this study. These species are grouped into 63 families. The fam-

ilies accompanying *S. aurata* are: Aglajidae; Alcyoniidae; Aporrhaidae; Ascidiidae; Asteriidae; Astropectinidae; Axinellidae ; Bothidae; Carangidae; Cardiidae; Cassidae; Centracanthidae; Cepolidae; Citharidae; Clupeidae; Cymothoidae; Dactylopteridae; Dasyatidae; Diogenidae; Dorippidae; Engraulidae; Epialtidae; Epizoanthidae; Gobiidae; Gorgoniidae; Hormathiidae; Inachidae; Loliginidae; Merlucciidae; Mullidae; Muricidae; Octopodidae; Ommastrephidae; Ophichthidae; Ophiuridae; Ostreidae; Pectinidae; Pelagiidae; Penaeidae; Pennatulidae; Pleurobranchaeidae; Plumulariidae; Pteriidae; Rajidae; Rhizostomatidae; Scalpellidae; Scophthalmidae; Scorpaenidae; Sepiidae; Serranidae; Soleidae; Sparidae; Sphyraenidae; Spongiidae; Squillidae; Stichopodidae; Tethydidae; Torpedinidae; Triakidae; Triglidae; Tritoniidae; Uranoscopidae; Zeidae.

Diversity and evenness

The results of Table 2 indicate that in the eastern region, the values of the Shannon index show a slight variation according to specific abundance and specific weight (3.16 to 3.58 bits). The Shannon index calculated from the specific weights has a value of 3.58 bits, with an evenness of 0.55. This regularity value characterizes a little homogeneous community. Instead, the Shannon index calculated from specific abudance is lower (3.16 bits), affecting the value of equitability (0.49) which translates into the little homogeneity of community defined in the eastern region.

Models of abundance and weight distribution

Overall, the three mathematical models of Motomura, Mac Arthur and Preston satisfactorily describe the structure of the community associated with the gilthead sea bream (Figs. 1, 2).

The rank-frequency diagrams and the rank-weight diagrams show that the Preston model fits better with the observed values (correlation coefficient> 0.92 and the variance ratios which are not far from 1) (Tables 3, 4).

The community associated with *S. aurata*, which is relatively a little diversified, shows largely dominant species; with regard to specific abundances, *Mullus barbatus* dominates very largely, followed by *Pagellus acarne* and *Trachurus trachurus* and then by *Pagellus erythrinus* and *Spicara smaris*. With regard to specific weights, *T. trachurus* and *M. barbatus* dominate, followed by *P. erythrinus* and *P. acarne*.

Zoological groups	Number of species	Percentage (%)
Fishes	42	48
Mollusks	17	19
Cnidarians	11	13
Crustaceans	9	10
Echinoderms	5	6
Sponges	2	2
Ctenophores	1	1
Tunicates	1	1

Table 1. Zoological groups accompanying *Sparus aurata* in the Algerian east coasts.

Associated fauna

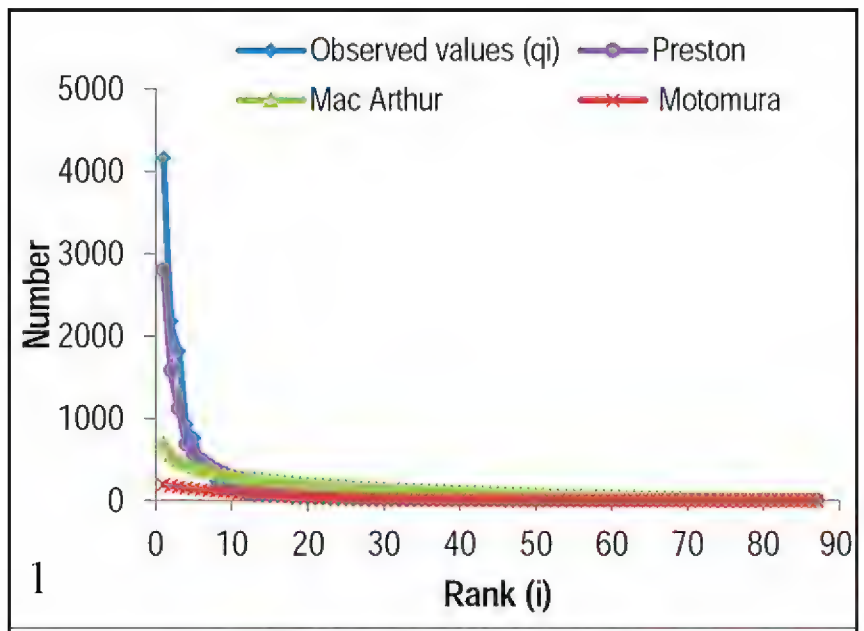
PCA was realized on a matrix of 88 lines (species) based on three initial variables: frequency, density and biomass. The first two axes explain more of 95% of the total variance (Table 5).

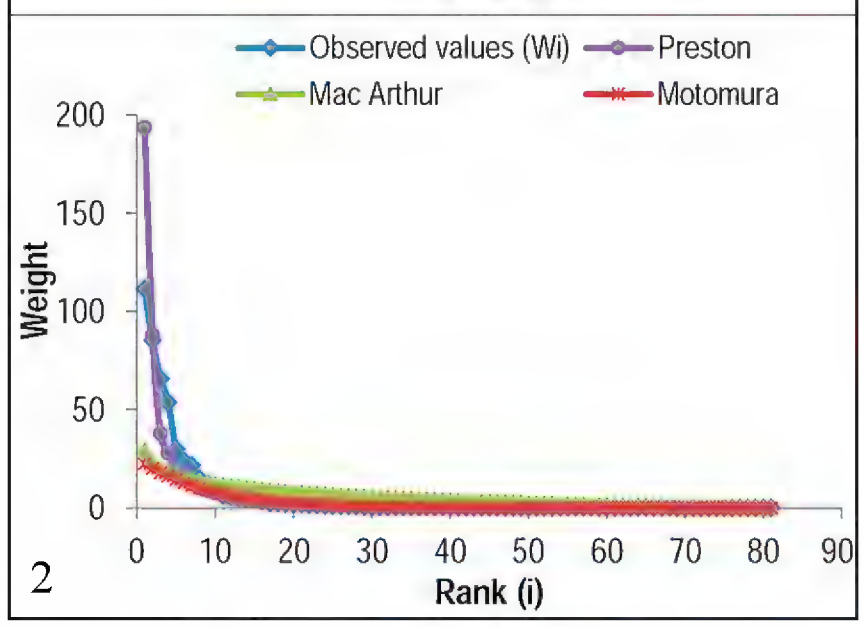
The correlation coefficient between the original variables and the principal axes (Table 6) highlights the contribution of each of these variables in the creation of these axes. The variable Fr contributes essentially to the creation of axis II, the factor II is therefore relative to the frequency. Axis I is constructed by the variables Dn and Dw, and it is therefore relative to abundances and biomasses.

The coordinates of the species allow their projection in the I-II factorial plane (Fig. 3). It should be noted that the most frequent species contribute weakly to axis I, they are therefore a little abundant with low biomasses; it is about: *Raja miraletus*, *Merluccius merluccius*, *Serranus hepatus*, *Citharus linguatula*, *Boops boops* and *S. smaris*. On the other hand, *M. barbatus*, *T. trachurus*, *P. acarne* and *P. erythrinus* show strong densities and biomasses, and low frequencies.

DISCUSSION

The result of the specific richness of the community associated with the gilthead sea bream *S. aurata* in the Algerian east coasts is 88 species. In the same region, the study on data of the oceanographic campaign of Thalassa highlights 58 species





Figures 1, 2. Adjustment of the models: number (Fig. 1) and weight (Fig. 2).

Index	Specific abundance	Specific weight
ISh	3.16	3.58
E	0.49	0.55

Table 2. Diversity index (ISh) and evenness (E) for community of the gilthead sea bream *Spaurus aurata* in the Algerian east coasts.

	Models		
Correlation coefficient	Motomura	Mac Arthur	Preston
r (qi,qth)	0.73	0.75	0.99
r (wi,wth)	0.91	0.83	0.92

Table 3. Adjustment of theoretical models (correlation coefficient).

	Models		
Correlation coefficient	Motomura	Mac Arthur	Preston
r (qi,qth)	0.73	0.75	0.99
r (wi,wth)	0.91	0.83	0.92

Table 4. Adjustment of theoretical models (variance ratio).

accompanying *S. aurata* (Chebel et al., 2014); this specific richness is much lower than our result. This difference could be explained by variations in environmental conditions occuring in the years between 1982 and 2012, which cause changes in the composition of populations living with *S. aurata*.

The values of the Shannon index and evenness are fairly low; they characterize a little homogeneous community. This situation is due to a large dominance of some species in the considered region. In the Algerian east coasts, Chebel et al. (2014) found almost the same values as our study; that is to say that the degree of diversity of the community associated with *S. aurata* is almost stable in the years between 1982 and 2012.

The application of abundance distribution models has allowed to highlight a young community with a dominance of *M. barbatus* for the specific abundances and a dominance of *T. trachurus* and *M. barbatus* for the specific weights. Chebel et al. (2014) mention that *M. barbatus* dominates for specific abundances and *P. acarne* and *M. barbatus* for specific weights. Thus, in relation to specific abundances, the dominance of *M. barbatus* did not change in the years between 1982 and 2012. On the other hand, the dominance of the species *P. acarne* has been replaced by that of *T. trachurus*; this could be related to the richness of nutrients and the good hydro-climatic conditions which are at the origin of the abundance of plankton, essential for the nutrition of the juveniles of *T. trachurus*.

Principal component analysis (PCA) shows that *M. barbatus* is the species most associated with *S. aurata* with a significant presence of *T. trachurus* and *P. acarne* and, to a lesser degree, *P. erythrinus*. This is explained by the feeding habits of these species which are close to that of the gilthead sea bream *S. aurata*; they feed on molluscs, decapods, annelids and fish (Stergiou & Karpouzi, 2002). The comparison between this result and that of Chebel et al. (2014) reveals that the species *M. barbatus* remains the most dominant species with the pres-

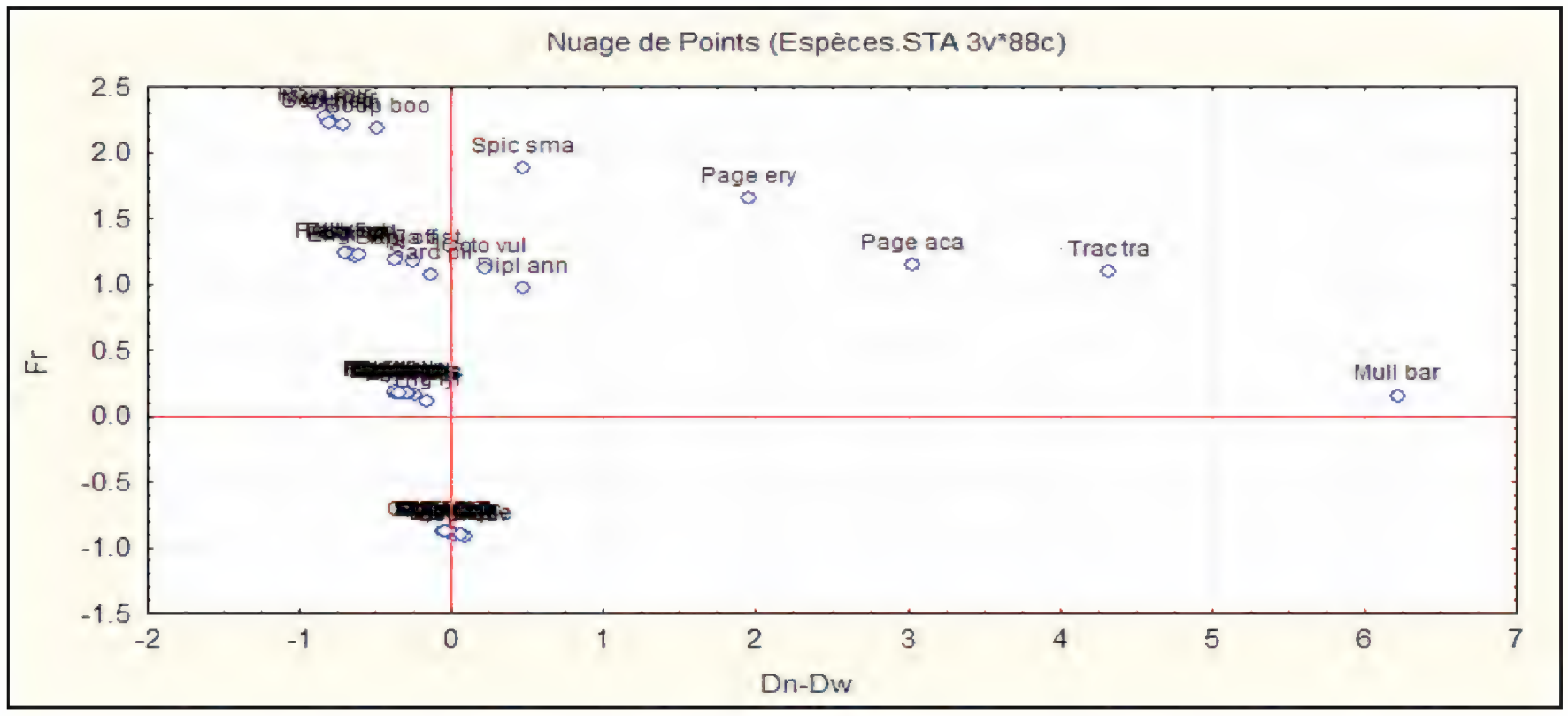


Figure 3. Projection of species in the plane I-II (Algerian east coasts).

Axes	Eigen values	Total percentage of variance	Cumulation of eigen values	Cumulation of percentage of variance
1	2.27	75.61	2.27	75.61
2	0.59	19.52	2.85	95.13
3	0.15	4.87	3	100

Table 5. Extraction of principal components and values of three axes (Algerian east coasts).

Initial variables	Factor 1	Factor 2
Fr	0.26	0.96
Dn	0.94	0.23
Dw	0.90	0.35

Table 6. Contribution of variables to the formation of axes I and II (weight marked>0.7).

ence of *T. trachurus* as a codominant species. This confirms the demersal character of *S. aurata* (Fischer et al., 1987; Djabali et al., 1993), but the prevalence of some semi-pelagic species such as *T. trachurus*, *B. boops* and *S. smaris* shows that the gilthead sea bream lives not only near the bottom but also in the semi-pelagic zone.

The results of this study allowed us to highlight a juvenile system. With regard to the associated fauna, it appears a little diversified but essentially composed by fish species.

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Inventory and geographical distribution of *Acacia* Mill. (Fabaceae Mimosaceae) species in Algeria

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ABSTRACT

The geographical distribution of the genus *Acacia* Mill. (Fabales Mimosaceae) in Algeria was determined after the prospect, localization and description of the various species populations overall Algerian territory. Twenty-four regions were prospected, based on relative species abundance. Among the ten-species found in Algeria, only *A. karroo* and *A. saligna* can be found in the whole country. However, there are some concentrations in certain northern regions. *Acacia decurrens* was only found in the Northeast, with high concentrations at the National Park of El Kala. Five of them are recorded in the southwest (*A. albida*, *A. ehrenbergiana*, *A. nilotica*, *A. seyal* and *A. tortilis*). *Acacia farnesiana* is indicated in the Northeast and the Northwest. *Acacia laeta* individuals were very rare. According to the climatic data during the years 2000-2016, the following species adapted to the annual pluviometry, that is lower than 100 mm: *A. albida*, *A. ehrenbergiana*, *A. laeta*, *A. nilotica*, *A. seyal* and *A. tortilis*. Three species (*A. karroo*, *A. farnesiana* and *A. saligna*) are in zones with an annual pluviometry between 250 and 500 mm). *Acacia decurrens* is located in a zone in which the annual precipitation exceeds 1000 mm. This study shows the distribution of the *Acacia* species in Algeria.

KEY WORDS

Acacia; Desert trees; distribution maps; aridity; Forestry.

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INTRODUCTION

The diversity of the biological resources constitutes, since a few decades, a central theme for several disciplines that conjugate their efforts, not only for its preservation, but also for its long-sustainable use. Indeed, the ligneous vegetation plays a fundamental role in the structure and the functioning of arid and semi-arid ecosystems (Mahamane & Mahamane, 2005). One of the most problems, urgent to solve today, is the restoration and reconstruction of degraded ecosystems. Reforestation of degraded landscapes can have positive effects on the ground, and allows regeneration of long-lasting ligneous communities (Cao et al., 2011).

For a successful reforestation campaign, the use of native species like some *Acacia* Mill. (Fabales Mimosaceae) trees is sometimes recommended (Foroughbakhch et al., 2001). Autochthonous species of *Acacia* are often adapted to drought, thermal and salt constraints (Fuentes-Ramírez et al., 2011; Kheloufi et al., 2016a). As such, they participate in grounds restoration and allow natural fertilization by fixing variable quantities of atmospheric nitrogen due to the

association of their roots with soil microorganisms (*Rhizobium*) (Boukhatem et al., 2012). Several *Acacia* species live frequently the vegetation in arid and semi-arid lands of sub-Saharan Africa (Richardson & Kluge, 2008). They are widely known and used by the local populations as forage legumes (Abdulrazak et al., 2000). The productivity and the stability of these forest ecosystems with *Acacia* trees are strongly dependent on water availability. Indeed, species of the genus *Acacia* are not very resistant to drought constraint in spite of their presence in arid and semi-arid circles (Gimeno et al., 2010). Most of them are drought-avoiding species. Their survival in these circles is especially due to the water uptake efficiency of their root systems. Salinity constraint can also be added to water deficit and can affect *Acacia* species from germination to the first stages of growth (Kheloufi et al., 2016a).

Recently, several works were undertaken for a better understanding of the *Acacia* species, which could allow a good plan for a fast and permanent reforestation in the regions where the grounds degradation expanded in Algeria (Mansouri, 2011; Kheloufi, 2017; Kheloufi et al., 2017). However, in spite of these species that are often used to explain certain ecological and physiological characteristics of the environment, very few works were interested in their real or potential distribution area in Algeria.

The cartography of areas occupied by various species can be made either on the basis collected data, or by compiling bibliographical data or collections of herbarium. The realization of maps in this work represents a contribution to *Acacia* species distribution in Algeria to fill potential knowledge gaps in this domain. Furthermore, a synthesis of various taxonomic names with a historical reference table was established to eliminate any confusion in the study of a defined species belonging to this genus.

MATERIAL AND METHODS

Study site

Algeria is riddled with a multitude of reliefs. The North is crossed from West to East by a double mountainous barrier (Tell Atlas and Saharan Atlas). The ground is covered with numerous forests in the center, with vast plains in the East and the Sahara, which represents 84% of the national territory. Algeria is located in North Africa, between the latitudes 37°4' N and 18°58' N and the longitudes 8°40' W and 11°59' E. Algeria is the largest country in Africa by area, which extends over 2,381.741 km^2. It is administratively divided into 48 regions.

Distribution maps

The realization of the real and potential distribution maps was based only on ground observations made over all the national territory. We did not consider herbarium collections because a valuable information was missing (Population characteristics where plant samples were collected). The method used for mapping species distributions corresponds to the real distribution area. Georeferenced distribution maps were realized by GIS software (ArcGIS 10.3). Moreover, we consider the data collected from the Forests Department and the National Parks, National Forest Research Institute (2013–2016). Geographical positions were recorded using a Magellan eXplorist 200 GPS Receiver.

Field data collection and inspection collect

Twenty-four regions were the object of diverse observations on the *Acacia* species distribution. The most important criterion in the choice of sites is the presence of one of the ten studied species. Every site is located at first with the GPS Receiver (Elevation, Latitudes and Longitudes). On every site, the global average mean surface was 10 000 m^2 (100 m×100 m), according to the recommendations of Küchler & Zonneveld (1988) for dry lands. The scale held to indicate the presence of every species was (> 50 individuals by 10 000 m^2).

The reserved environmental factors vary according to a climatic gradient from North to South of the country. The climate is the most important environmental factor influencing forest growth and species distribution (Guisan & Thuiller, 2005).

Aridity characterization and climatological classification

In this study, we have retained the annual mean precipitation of of 17 year-period (2000–2016),

annual average temperature and elevation. Climatic data was provided by the World Climate Data: Tutiempo available on the website: www.tutiempo.net.

Aridity index of De Martonne of each habitat was calculated by the equation established by De Martonne (1926), and this index allowed the species to be classified according to the aridity of their respective habitats. This classification was used in the presentation of the results.

$$IM = \frac{P}{T + 10}$$

IM = De Martonne Aridity Index

P = Annual average rainfall in mm.

T = Annual average temperature in degrees centigrade.

RESULTS AND DISCUSSION

Distribution by Climate

Algeria's geographical diversity produces a range of climatic conditions. The northern part of the country has a Mediterranean climate with mild, wet winters and hot, dry summers. The plateau region has a semi-arid climate, with greater contrasts between summer and winter. Temperatures vary the most in the Sahara desert region, which has an arid climate with almost no annual rainfall. Summer temperatures average about 25°C in the northern coastal region, 27°C in the plateau, and 34°C in the desert, where readings as high as 49°C have been recorded. Average winter temperatures range from about 5°C on the plateau to about 11°C in the north; winter lows in the desert can plummet to as low as -10°C. The hot, dusty wind known as the Sirocco often blows in the summer.

The Algerian ground seems accommodating an interesting species diversity of *Acacia* genus with rustic character, which survive in extreme pedoclimatic conditions and which would be good to rehabilitate and to introduce into reforestation programs. The species listed during the site prospecting were: *A. albida*, *A. laeta*, *A. ehrenbergiana*, *A. nilotica*, *A. seyal* and *A. tortilis*, considered as native species (Ozenda, 1977), while those introduced were: *A. farnesiana*, native of America (Berhaut, 1975), *A. karroo*, native of South Africa (Palmer & Pitman, 1972) and finally *A. saligna* and *A. decurrens* both native of Australia (Auld, 1983). Average annual precipitation, minimal and maximal temperatures (2000–2016), and site elevation are shown in Table 1.

According to the Aridity index of De Martonne (Figure 11) and the bioclimatic classification of Algeria, which spread out over a 17-year period (2000–2016) (Table 1), *A. albida*, *A. ehrenbergiana*, *A. laeta*, *A. nilotica*, *A. seyal* and *A. tortilis* are listed in Saharan regions (precipitation < 100 mm), *A. farnesiana* is listed in dry regions (precipitation between 100–300 mm), *A. karroo* and *A. saligna* were found in high numbers in semi-arid regions (precipitation ranges between 300-600 mm), and finally *A. decurrens* is listed only in a region with humid Mediterranean climate (precipitation > 1000 mm). The drought undergone by plants can thus differ significantly from the aridity index.

The knowledge of temperature averages can influence the distribution areas as well as the reforestation programs because it determines the choice of forest species used according to their resistance or not in the extreme temperatures. However, these data do not reflect exactly the weather conditions of the sites, knowing that the climatic data are recorded in meteorological stations located in very precise places. We can suppose that there are differences in temperature with various places because the regions have important surfaces. However, these

Acacia Species	Average annual precipitation (mm)	Average annual temperature		Elevation (m)
		T min (°C)	T max (°C)	
A. albida	106.3	16.4	30.2	539
A. decurrens	1015.5	12.8	22.9	70
A. ehrenbergiana	49.2	16.7	31.8	709.5
A. farnesiana	257.8	13.3	26.6	274.5
A. karroo	386.3	11.6	23.7	713.5
A. laeta	94.2	15.7	29.7	1170
A. nilotica	80.7	16.7	31.2	466.5
A. saligna	499.3	12.3	24.1	446.7
A. seyal	125.4	16.4	29.4	609
A. tortilis	73.9	16.3	31.0	645.5
Mean (24 regions)	268.9	14.9	28.1	564.4
SEM	218.9	1.8	2.9	205.1

Table 1. Mean values and standard error of climatic factors and site elevation where the species is present.

observations remain a good indication of weather conditions on the various sites.

Distribution by region and biological characteristics

The distribution areas of *Acacia* species are represented according to a North-South climatic gradient and always in the territorial limits of Algeria (Figs. 1–10 and Figs. 12–16). Except of *A. karroo*, species distribution of *A. albida*, *A. ehrenbergiana*, *A. laeta*, *A. nilotica*, *A. seyal* and *A. tortilis* do not seem to cross the North of Algeria. However, the lack of data on this observation does not allow to confirm with certainty this hypothesis.

According to the morphology of *Acacia* species listed in Algeria, there are three groups of species. In the first group, they are the thorny with compound leaves (*A. albida*, *A. ehrenbergiana*, *A. farnesiana*, *A. karroo*, *A. laeta*, *A. nilotica*, *A. seyal* and *A. tortilis*). The second regroups with *A. decurrens*, which is not a thorny tree, but has compound leaves. The last group is represented by *A. saligna*, which is not a thorny species, but has phyllodes (petiole or rachis modified into a leaf). These morphological characters confer an adaptation for every species to its environment.

Table 2 represents a synthesis of various taxonomic names with a historical reference of every species listed in our study. It is a bibliographical synthesis of certain works which handle the ligneous species and their systematics through time.

Biological characteristics of the various species were based on observations, bibliographical research and comparisons between the listed species.

Acacia albida Delile, 1813

Acacia albida is a multipurpose tree widely distributed in semi-arid regions (Fig. 1). The most remarkable distinctive character of this species is its reverse phenology. Leafed in dry season, defoliated in rainy season (Wood, 1992). The simple observation of leafing trees, flowering or fruiting, reveals a great variability within the same population. *Acaciua albida* is a species with high ecologic plasticity, as it thrives on almost any type of soil but is most frequently found growing on rocky, muddy, or sandy substrate. The popular medicine or the family pharmacy also revealed a very interesting advantage of this species in the treatment of bronchopulmonary infections, head troubles, high blood pressure, and malaria (Sheded et al., 2006).

Acacia decurrens Willd., 1806

This species is one of the most represented in the northeast of Algeria, with much more populations concentrated in El-Kala's National Park (Fig. 3). *Acacia decurrens* is a Mediterranean Basin species. It is a fast-growing tree with well-developed vegetation (Kheloufi et al., 2016a).

Acacia ehrenbergiana Hayne, 1827

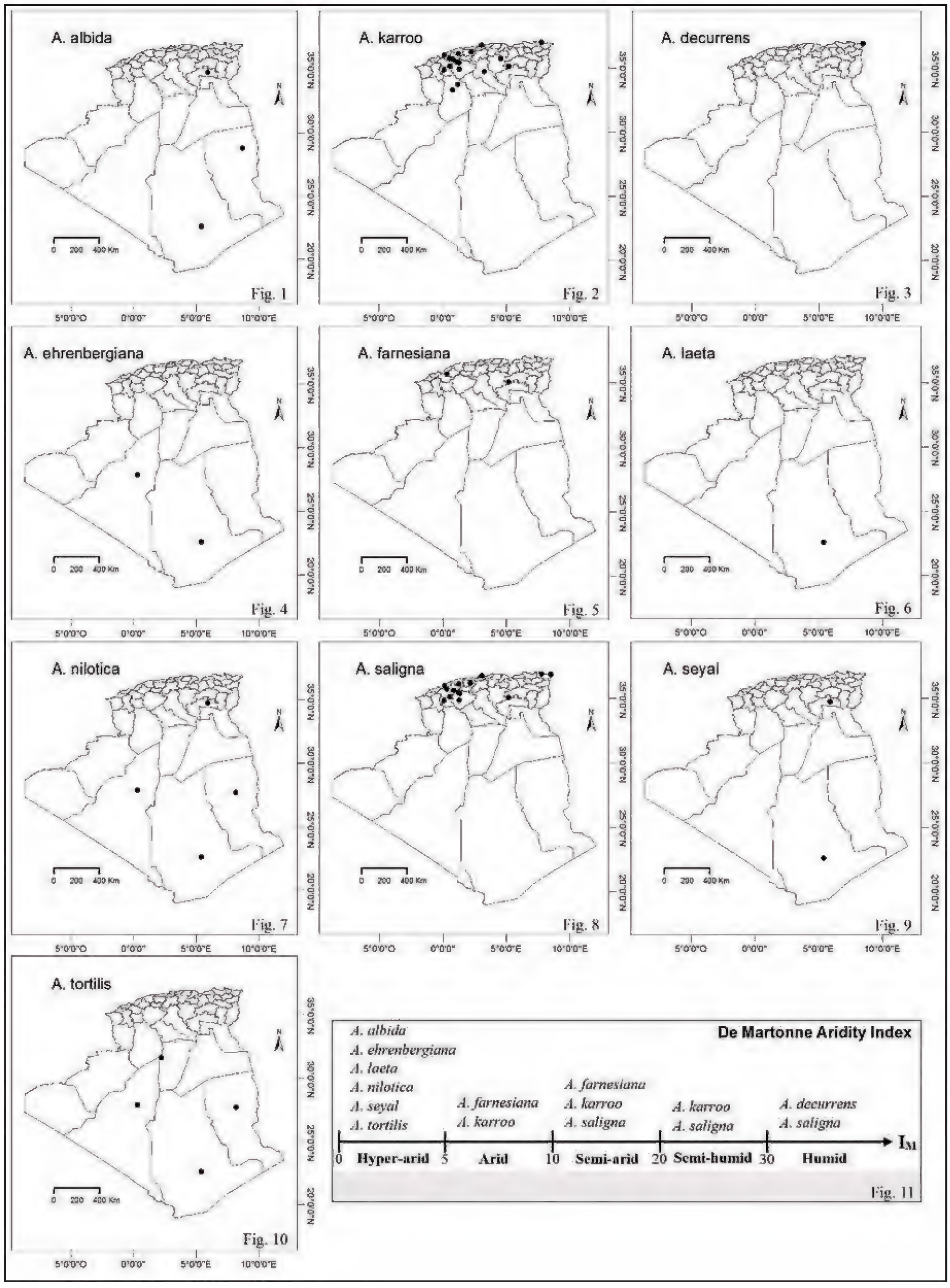
This species was found on clayey, rocky, and sandy soil in the dry zones. By exploiting the data sources, it has been showed that *A. ehrenbergiana* was located only in two places (Adrar and Tamanrasset) along water courses (Fig. 4).

Acacaia farnesiana (L.) Willd., 1806

Acacia farnesiana is native to tropical America (Traveset, 1990). It was introduced in all the tropical regions where it has often naturalized. It is considered as pantropical today. This shrub is very ramified with grey-brown bark, its abundant branches are armed with strong thorns (Prickles). The straight and white thorns are 1.5 to 5 cm in length. *A. farnesiana* is a drought-tolerant mimosa, but not cold-tolerant (Maldonado-Magaña et al., 2011). It is listed only in two specific zones, in Relizane to prevent soil erosion of the national road, and Batna (M'doukel) to combat desertification by dune fixing (Fig. 5).

Acacia karroo Hayne, 1827

It is one of the fastest of the fast-growing trees which takes place at the second position after *A. saligna*. Leaves are composed by many leaflets. Branches are armed with very long sharp thorns. This tree is a reliable source of forage due to foliage, flowers and pods. The tree attracts insects by its flowers and its gum, and attracts insectivorous birds. It is a considerable source of shade in the dry regions and a site of nesting for several species of birds. The wood is hard, tough, durable and its gum is edible (Anderson & Pinto, 1980). This spe-



Figures 1–10. Geographical distributions of *Acacia* species in Algeria.

Figure 11. Classification of *Acacia* species following De Martonne Aridity Index (IM) in Algeria.

cies is listed in most of the Algerian territory and its behavior varies from an ecotype to another (Fig. 2).

Acacia laeta R. Br., 1814

It is found only in the south of the country (Fig. 6). This species colonizes almost all types of soil. *Acacia laeta* is a shrub of 4–10 m tall with fissured, grey-green bark. Prickles in pairs, claw-shaped, just below each node, recurved and sometimes with a third intermediate prickle which is curved towards the top (Anderson et al., 1968). Leaves are composed and are very characteristic with their tough aspect and their pubescence especially on the lower face.

Species	Synonymes	References
A. albida	*Acacia albida* Delile, 1813 *Faidherbia albida* (Delile) Chev., 1934	(Arbonnier, 2009)
A. decurrens	*Mimosa decurrens* Donn, 1796 *Acacia decurrens* Willd., 1806 *Acacia angulata* Desv., 1814	(Moffett & Nixon, 1974)
A. ehrenbergiana	*Acacia ehrenbergiana* Hayne, 1827 *Acacia flava* Schweinf (Forssk.) Schweinf., 1896	(Arbonnier, 2009)
A. farnesiana	*Acacaia farnesiana* (L.) Willd., 1806 *Acacia pedunculata* Willd., 1806	(Clarke et al., 1989)
A. karroo	*Acacia churnea* sensu auct. non (L. f.)Willd., 1806 *Acacia horrida* sensu auct. non (L.) Willd., 1806 *Acacia karroo* Hayne, 1827 *Acacia natalitia* E. Mey., 1836 *Acacia inconflagrabilis* Gerstner, 1948	(Jami et al., 2012)
A. laeta	*Acacia laeta* R. Br., 1814 *Acacia trentiniani* A. Chev., 1901	(Arbonnier, 2009)
A. nilotica	*Acacia arabica* var. *tomentosa* Benth., 1842 *Acacia nilotica* subsp. *tomentosa* (Benth.)Brenan, 1957	(Arbonnier, 2009)
A. saligna	*Mimosa saligna* Labill., 1806 *Acacia saligna* (Labill.) H.L. Wendl., 1820 *Acacia cyanophylla* Lindl., 1839 *Acacia lindleyi* Meisn., 1844 *Racosperma saligmum* (Labill.) Pedley, 1987	(Dhileepan et al., 2006)
A. seyal	*Acacia seyal* Delile, 1813	(Arbonnier, 2009)
A. tortilis	*Acacia raddiana* Savi, 1830 *Acacia tortilis* var. *pubescens* A. Chev., 1927 *Acacia tortilis* fo. *raddiana* (Savi) Roberty, 1948 *Acacia tortilis* var. *raddiana* (Savi) Brenan, 1957	(Arbonnier, 2009)

Table 2. Bibliographical synthesis of various taxonomic names of ten *Acacia* species listed in Algeria.

Acacia nilotica subsp. *tomentosa* (Benth.) Brenan, 1957

Two subspecies of *A. nilotica* (*nilotica* and *tomentosa*) are known in Algeria. They require several types of soil and occupy various distribution areas. As this study does not consider this differentiation in subspecies, the distribution is relatively uniform (Fig. 7). *Acacia nilotica* is native to dry areas of tropical Africa and western Asia (Giri et al., 2007). Leaves have a considerable nutritional value and are especially used as forage supply for ruminants (cows, sheep and goats) (Kheloufi & Mansouri, 2017). *Acacia nilotica* trees contribute to improve the soil characteristics and can be used as firewood (Lal & Khanna, 1994).

Acacia saligna (Labill.) H.L. Wendl., 1820

It is the only *Acacia* tree with phyllodes present in Algeria. Adult phyllodes change from juvenile bipinnately compound leaves to phyllodes. This species colonizes all the northern Algeria (Fig. 8). This tree tolerates a wide variety of soil (even alkaline soils) and behaves normally close to very saline soils (Sebkha, chott) and coasts. Indeed, *A. saligna* can tolerate salt spray, hot coastal sun, extreme winds and sandy soil (Mansouri, 2011). It is used for the creation of good windbreak, and it is one of the fast-growing species. The best example is the project of sand quarry reforestation in association with the selected rhizobia by Mansouri (2011) in the region of Aïn Temouchent (Northwest of Algeria). The zone is located at 2 meters of altitude and 400 meters from the coast. The 1840 planted trees of *A. saligna* develop really well this day by protecting a broad biodiversity and preventing soil erosion. This species, due to high rusticity and good adaptation, is going to be used as a pioneer species, promoting the improvement of soil fertility in short periods of time, and promoting a better development of other, more productive species.

Acacia seyal Delile, 1813

Acacia seyal is a shrub species, which grows on gravel, rocky, and sandy grounds. Branches exude generally a translucent gum. Leaves are composed by a series of opposing leaflets and have an extremely short petiole. This study re-

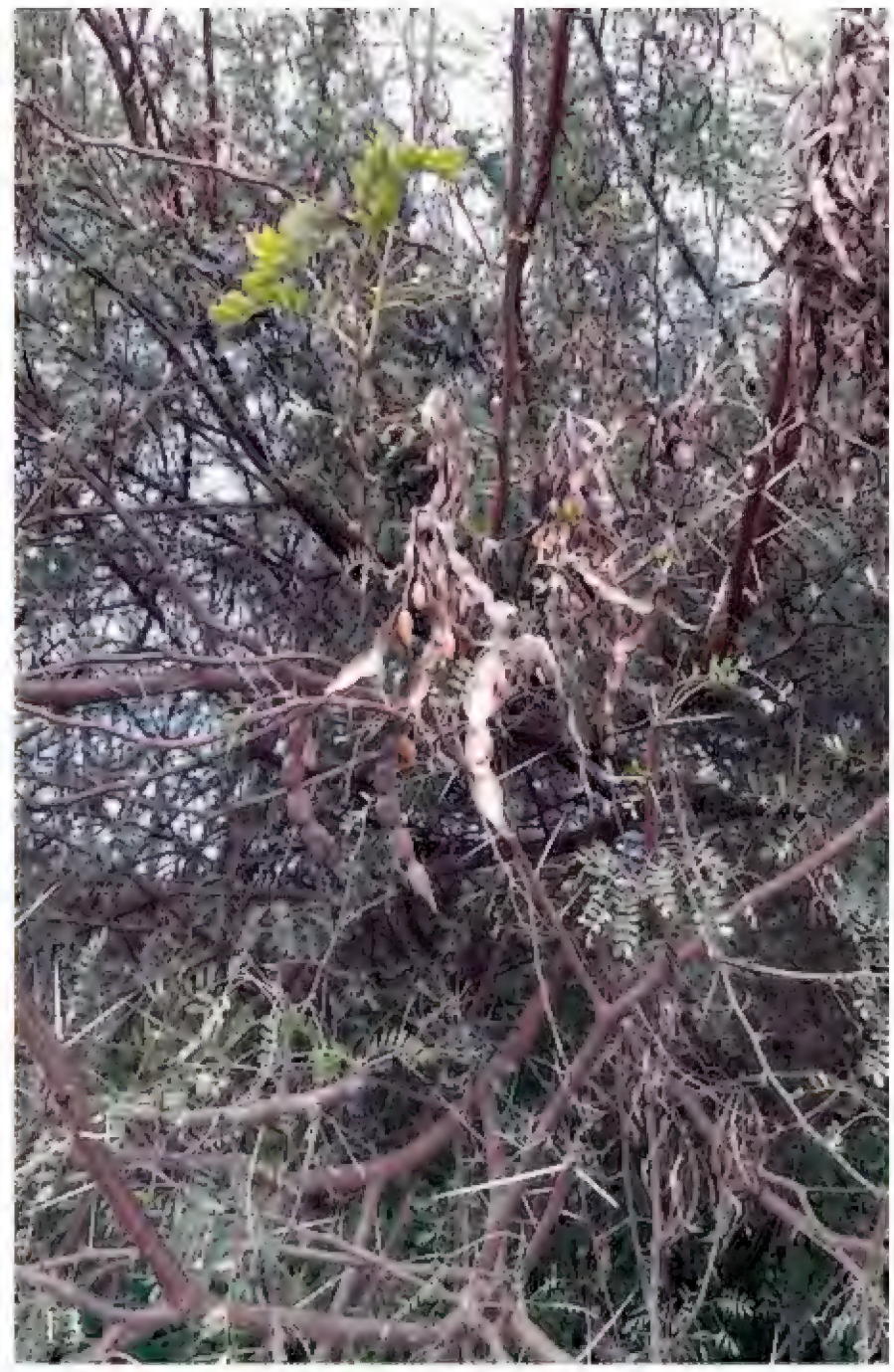


Figure 12. *Acacia farnesiana*, Relizane, Algeria. Figure 13. *Acacia karroo*, Oran, Algeria.
Figures 14, 15. *Acacia saligna*, Aïn Temouchent, Algeria.

Figure 16. *Acacia tortilis*, Tamanrasset, Algeria.

vealed its presence in the South with another presence in the region of Biskra (Fig. 9). The height that this tree can reach is 17 meters and 60 cm in diameter at breast height. It is common in several parts of Africa, especially to the North of the equator (Menzies et al., 1996).

Acacia tortilis subsp. ***raddiana*** (Savi) Brenan, 1957

Acacia raddiana is the most common tree found in the Sahara (Coughenour & Detling, 1986). It is a symbol of the desert in northern Africa. Among all the Acacia species located in Algeria, *A. tortilis* subsp. *raddiana* is apparently the most bound to the desert (Fig. 10). It is a pioneer species of the dry ecotypes. It is a slow-growing species when compared to other *Acacia* species, and constitute a major element that allow the preservation of ecological balance and the fight against desertification (Kheloufi et al., 2016b). The various parts of the species: roots, leaves, pods, gum and bark are very useful for medical, pastoral and commercial purposes (Al-Fatimi et al., 2007). *Acacia tortilis* grows generally in rocky, muddy, and sandy grounds.

CONCLUSIONS

The aridity of a region is not only determined by the climatic factors (rainfall and temperatures), but also by other factors which are topographical relief, wind speed which affect directly the evaporation, and ecolopedological conditions. Each abiotic condition, be it mining, geographical, or pedological (rainfall, wind, nature of the soil, geographical location, altitude, etc.) is added to the influence of human activity (reforestation, deforestation) to establish a specific distribution of each plant species, in space and time. By considering this species distribution and the specific wealth, acacias establish good indicators of the ecological zones in Algeria. This good concordance is related to the quantity and to the quality of the data on one hand, and to the ecological characteristics as well as to the importance of the species population on the other hand.

The distribution maps give essential tools in the understanding of the species ecology and serve the actions of natural resources preservation. The interacting effects of environmental temperature and spatial scale on species diversity using our extensive databases on tree distributions divided Algeria

in two large separate regions. Therefore, *Acacia* trees are, with regard to the obtained results, good indicators of climatic zones in Algeria. Some species present the elements of appreciation of the land conditions as the presence of the water or a specific ground.

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Biodiversity Journal, 2018, 9 (1): 61–64

New records of priapium fish, *Neostethus lankesteri* Regan, 1916 (Atheriniformes Phallostethidae), from the mangrove area of Andaman coast and lower Gulf of Thailand

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ABSTRACT A priapium fish, *Neostethus lankesteri* Regan, 1916, (Atheriniformes Phallostethidae) is newly recorded from the mangrove area of Andaman coast and lower Gulf of Thailand. Description and distribution data of a priapium fish is provided here.

KEY WORDS *Neostethus lankesteri*; Phallostethidae; Andaman coast; Gulf of Thailand.

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INTRODUCTION

The priapium fish genus *Neostethus* Regan, 1916, is distributed in Southeast Asia only (Myers, 1928; Parenti, 1984). First record of *Neostethus* in Thailand was reported by Myers (1937: sub *N. siamensis*), where Siam refers to the old name of Thailand, from the estuary of Chantaburi River, Southeast Basin, Thailand, this species was considered a junior synonym of *N. lankesteri* Regan, 1916 (Parenti, 1989). Currently, in Thailand, *N. lankesteri* Regan, 1916, is known only from the estuary of Chantaburi River, Southeast Basin, estuary of Petburi Basin, estuary of Maeklong and Chao Phraya Basin (Kunlapapuk et al., 2012; Suksri et al., 2015).

In a survey project in lower Gulf of Thailand and Andaman coast, Thailand, during July–November 2017, the author found several specimens of *N. lankesteri* in the mangrove area of Khanom River, Khuan Thong Subdistrict, Khanom District, Nakhon Si Thammarat, lower Gulf of Thailand and the mangrove area of Thalang District, Phuket Province, Andaman coast, Thailand, which is a new record of *N. lankesteri* in this region.

ACRONYMS. Standard length: SL; head length: HL.

RESULTS

Systematics

Ordo ATHERINIFORMES Rosen, 1966
Familia PHALLOSTETHIDAE Regan, 1913
Genus *Neostethus* Regan, 1916

Neostethus lankesteri Regan, 1916

EXAMINED MATERIAL. Three specimens, mangrove area of Mark Pok Anusorn, Mai Khao Subdistrict, Thalang District, Phuket Province, Andaman coast, Thailand, VII.2017, legit Sitthi Kulabtong; eleven specimens, mangrove area of Khanom River, Bangku Village, Khuan Thong Subdistrict, Khanom District, Nakhon Si Thammarat, lower Gulf of Thailand, XI.2017, legit Sitthi Kulabtong (Fig. 1).

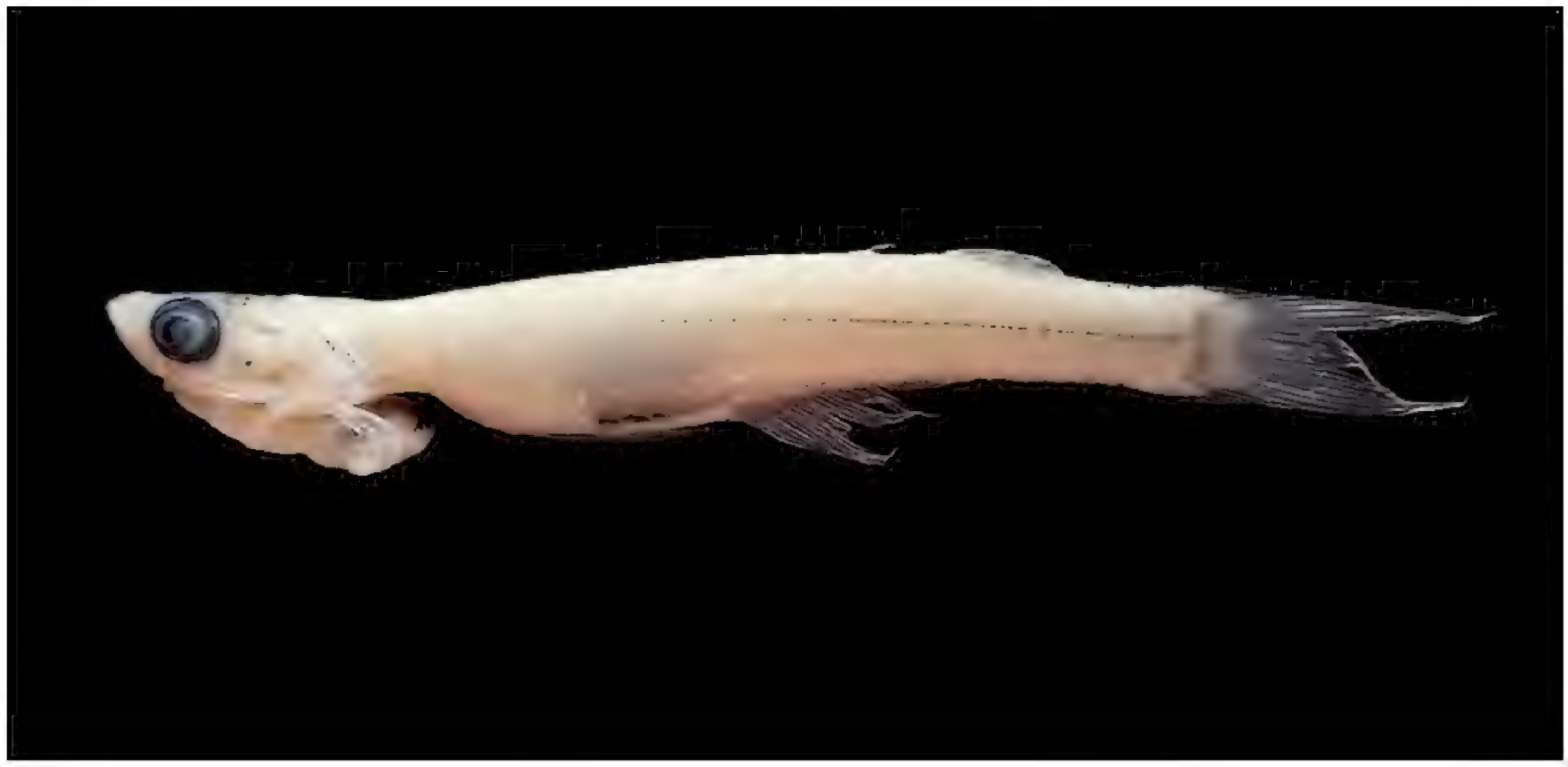

Figure 1. *Neostethus lankesteri*, 35 mm SL (male) from mangrove area of Khanom River, lower Gulf of Thailand.

Figure 2. Mangrove area of Khanom River (4 kilometers from Khanom Estuary), Khanom District, Nakhon Si Thammarat, lower Gulf of Thailand.

Figure 3. Mangrove area of Thalang District (1 kilometer from the sea), Phuket Province, Andaman coast, Thailand.

DESCRIPTION. *Neostethus lankesteri* is compressed, body depth is 15.4–18.7 %SL. Body width is 7.2–11.1 %SL. Scales in lateral series are medium to large, lateral series scales include 23–27 scales, predorsal scales are 10–12. Head length is 27.6–33.3 %SL. The eyes are large, eye diameter is 23.5–31.8 %HL (6.5–9.9 %SL). Post orbital length is 52.9–56.1 %HL (14.6–18.7 %SL), snout length is short, with 14.7–17.1 %HL (4.1–5.7 %SL) and interorbital width is 44.5–48.7 %HL (8.7–10.1 %SL). Predorsal fin length is 69.1–73.4 %SL, prepectoral fin length is 31.4–32.5 %SL, prepelvic fin length is 44.3–48.2 %SL and preanal fin length is 58.5–63.7 %SL. Caudal peduncle depth is 10.6–13.1 %SL. Pectoral fin is short, not reaching beyond anus, the pectoral fin length is 12.6–16.3 %SL and 8–9 branched fin rays. Pelvic fin is short, not reaching beyond anus, the pelvic fin length is 7.4–8.9 %SL with 7 branched rays. Anal fin base is longer than dorsal fin base, the anal fin base length is 12.8–17.1 %SL, dorsal fin with 2 unbranched rays and 7 branched rays and anal fin with 3 unbranched rays and 5 branched rays. The dorsal fin base length is 11.2–16.7 %SL.

BIOLOGY AND DISTRIBUTION. In this study all specimens of *N. lankesteri* were found in the mangrove area of Khanom River (4 kilometers from Khanom Estuary, salinity more than 20 ppt; depth about 1 m or more, mud on the bottom), Bangku Village, Khuan Thong Subdistrict, Khanom District, Nakhon Si Thammarat, lower Gulf of Thailand (Fig. 2) and the mangrove area of Mark Pok Anusorn (1 kilometer from the sea, salinity more than 20 ppt; depth about 1 m or more, sandy mud on the bottom), Mai Khao Subdistrict, Thalang District, Phuket Province, Andaman coast, Thailand. In Thailand, this species is known only from the estuary of Chantaburi River, Southeast Basin, estuary of Petburi Basin, estuary of Maeklong and Chao Phraya Basin. It is a new record for the lower Gulf of Thailand and Andaman coast, Thailand (Fig. 3).

ACKNOWLEDGEMENTS

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A new species of the genus *Stereocephalus* Lynch, 1884 from Paraguay (Coleoptera Staphylinidae Paederinae)

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ABSTRACT *Stereocephalus agostii* n. sp. (Coleoptera Staphylinidae Paederinae) from Paraguay is described and a new key to species of the genus *Stereocephalus* Lynch, 1884 is proposed.

KEY WORDS Coleoptera; Staphylinidae; Paederinae; *Stereocephalus*; *Stereocephalus agostii* n. sp.

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INTRODUCTION

Stereocephalus Lynch, 1884 (Coleoptera Staphylinidae Paederinae) was originally described by Lynch (1884) for one species, *S. seriatipennis* Lynch, 1884, from Argentina. Bernhauer (1939) added a second species from the same country. In 1979, two Argentine species were synonymized and three new Brazilian species were described by Herman (1979). Here, a new species from Paraguay is described.

Terminology. The surface of the aedeagus, generally considered ventral in recent years, was cited as dorsal by Herman (1979). A lateral view of the apical portion of the aedeagus resembles the form of a poll pick, which is a single pointed miner's pick with a short poll (or striking head). "Poll pick" is used in the description and key.

RESULTS

Systematics

Ordo COLEOPTERA Linnaeus, 1758
Familia STAPHYLINIDAE Lameere, 1900
Subfamilia PAEDERINAE Fleming, 1821

Genus ***Stereocephalus*** Lynch, 1884

TYPE SPECIES. *Stereocephalus seriatipennis* Lynch, 1884

DIAGNOSTIC FEATURES. The unique and single most diagnostic feature of *Stereocephalus* is the broad, compressed, and glabrous fourth segment of the maxillary palpus (Herman, 1979: figs. 22, 23). Other distinguishing characters include the deeply emarginate, edentate labrum (Herman, 1979: fig. 6), and the bent first antennomere (Herman, 1979: fig. 7).

DISTRIBUTION AND BIOLOGY. The genus is found in Argentina, Paraguay, Brazil, Peru, Ecuador, Venezuela and Costa Rica.

REMARKS. Few specimens are known for the genus and specimens have been found in few localities. Nearly all of the reported localities each yielded only one specimen. The most commonly collected species, *S. seriatipennis*, is widespread. It is probable that more species of this genus will be found.

Stereocephalus agostii n. sp. (Figs. 1–3)

TYPE MATERIAL. Holotype: Male, [Label 1] "*Paraguay 02.10.2005 Cordillera Piraretá Carlos Aguilar lgt.*" [Label 2] "*Holotypus* Stereocephalus agostii *sp. n. Matějíček det. 2017*". Paratypes (2): female, "*Paraguay 02.10.2005 Cordillera Piraretá Carlos Aguilar lgt.*"; female "*Paraguay 15-10-2005 Cordillera Departamento, Naranjo, Carlos Aguilar lgt*".

Specimens included in this study are deposited in the private collections of the author.

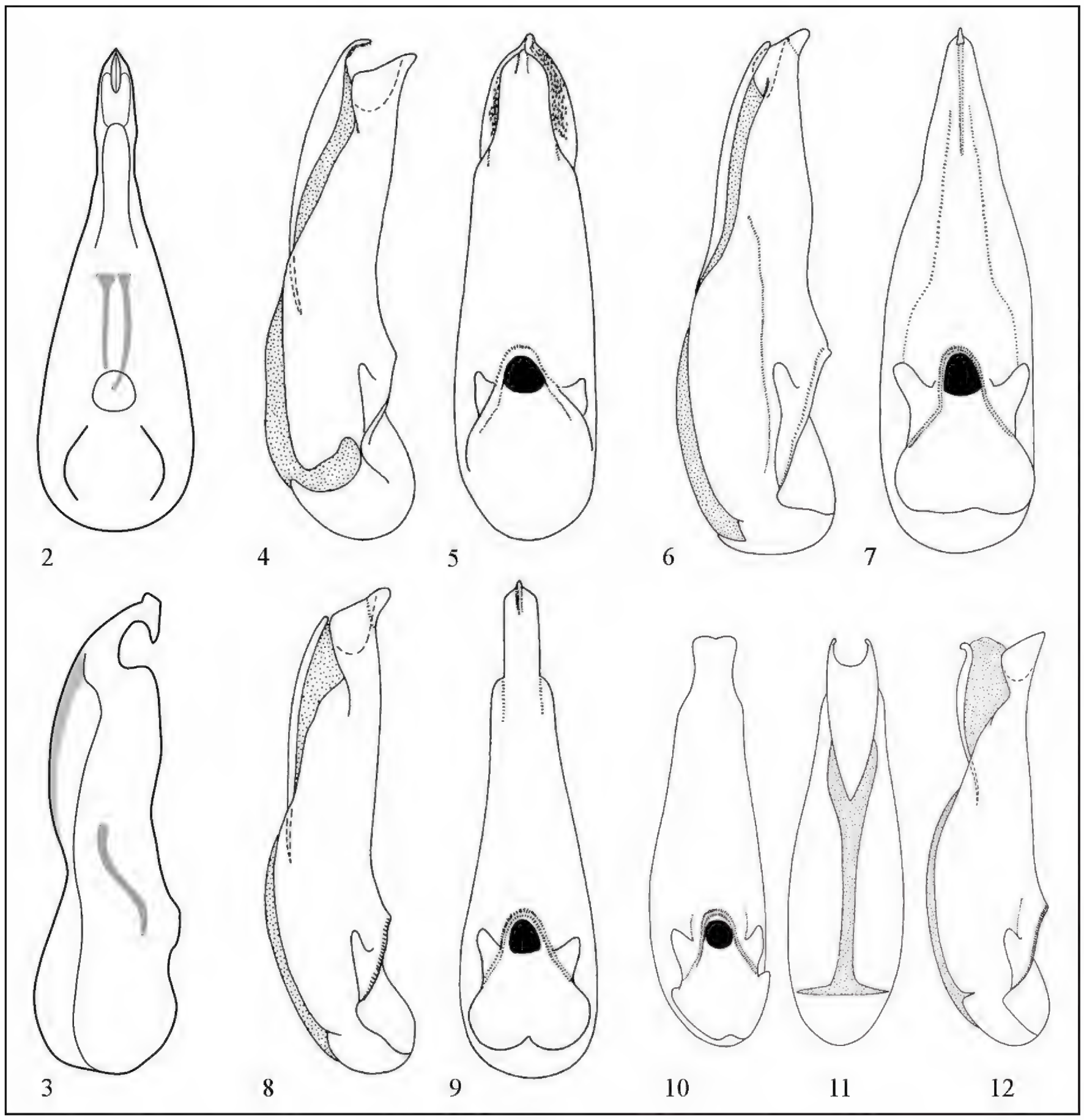
TYPE LOCALITY. Paraguay: Departamento Cordillera, Salto Piraretá, 25°30'S, 56°55'W.

Fig. 1. *Stereocephalus agostii* n. sp., holotype.

DIAGNOSIS. The posterior portion of the ventral sclerite of the aedeagus has the form of a clublike, single pointed miner's pick (Fig. 3) with a short poll or striking head; the pick is moderately long and anteriorly directed. This poll pick configuration separates the males of *S. agostii* n. sp. from all congeneric species.

DESCRIPTION OF HOLOTYPE. Length 5.5 mm. Body dark reddish brown. Antennae pale reddish brown. Legs yellowish brown. Dorsum of head (Fig. 1) densely punctate, punctures umbilicate; dorsum of head strongly shining between punctures and with two, polished, glabrous, transverse, median spots. Head longer than wide; postocular lateral margin feebly rounded; basal angles strongly rounded. Eyes moderately large and slightly protuberant. Pronotum (Fig. 1) slightly longer than wide; surface moderately and densely punctate, with moderately wide, midlongitudinal, glabrous strip, and short, narrow, glabrous strip laterad of median strip. Elytra (Fig. 1) densely punctate; punctures of dorsal surface arranged in longitudinal rows. Abdominal segments with moderately dense pubescence; terga III to VII with dense ground sculpture across base and polished from near middle to apical margin. Sternum VII with truncate posterior margin. Sternum VIII damaged, with median emargination, only apical curve of emargination visible; depth and width of emargination unknown.

Aedeagus with median lobe, in ventral view (Fig. 2), tapered from just beyond posterior margin of basal foramen to about apical third then parallel to apex; ventral surface moderately compressed to form broad ridge with weakly developed midlongitudinal carina beginning just beyond basal foramen and extending apically apex of median ridge; apex of median ridge strongly rounded in ventral view; median ridge in lateral view, ending abruptly and sharply ascending (Fig. 3); apical sixth of median lobe in ventral view parallel-sided to pointed apex; apical sixth of median lobe, in lateral view, with form of head of poll pick (Fig. 3); head of pick about one-tenth of length of median lobe, ventral edge carinate and broadly convex in lateral view; point of pick well separated from apex of median ridge; poll of pick small and strongly rounded. Base of median lobe and internal sac unavailable for study because of damage.



Figures 2–12. Aedeagi, in ventral and lateral view, of *Stereocephalus* (eccept new species, all by Herman, 1979). Figs. 2, 3: *S. agostii* n. sp., holotype. Figs. 4, 5: *S. ruhus*. Figs. 6, 7: *S. myrigeus*. Figs. 8, 9: *S. seriatipennis*. Figs. 10-12: *S. rinnanus.*

VARIABILITY. The two females paratype are larger than the male, respectively measuring 5.8 mm and 6.2 mm. External characters the same as the holotype male.

ETYMOLOGY. Named in honour of our colleague and my friend Mauro Agosti (1970–2017) (Brescia, Italy), an excellent specialist in Carabidae.

DISTRIBUTION. Known only from two localities in Cordillera Departamento, in southern Paraguay east of Asunción.

REMARKS. The base of the aedeagus and the surfaces surrounding the emargination of sternum VIII of the holotype were severely damaged. However, the apical portion of the aedeagus of *S. agostii* n. sp. is so distinct that there is no doubt of the validity and defining features of the new species. The apical portion of the left mandible is broken off, but still attached to the mounting plate.

Key to males of *Stereocephalus*

1. Dorsum of head with two impunctate, polished, medial spots (Herman, 1979: fig. 1)…....3
-. Dorsum of head without impunctate, polished spots (see Herman, 1979: figs. 38, 45)…....2

2(1). Aedeagus with apex of dorsal sclerite punctate (Figs. 4, 5; Herman, 1979: fig. 37); Brazil.....
.....*S. ruhus* Herman, 1979
-. Aedeagus with apex of dorsal sclerite deeply bifurcated (Figs. 6, 7; Herman, 1979: fig. 42); Brazil.....…*S. myrigeus* Herman, 1979

3(1). Aedeagus, in lateral view, with ventral sclerite abruptly ascending subapically and with poll pick-like or clublike apical ornamentation (Fig. 3).....…
…..…….....……*S. agostii* n. sp.
-. Aedeagus, in lateral view, with ventral sclerite gradually or moderately curved to pointed apex (Herman, 1979: figs. 12, 24)….....….4

4(3). Ventral sclerite of aedeagus, in ventral view, with slender, pointed apex (Figs. 8, 9; Herman, 1979: fig. 11)…....*S. seriatipennis* Lynch, 1884
-. Ventral sclerite of aedeagus, in ventral view, with shallowly emarginate posterior margin (Figs. 10–12; Herman, 1979: fig. 26) .....
.....*S. rinnanus* Herman, 1979

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Biodiversity Journal, 2018, 9 (1): 69–72

Coexistence of *Henosepilachna elaterii* (Rossi, 1794) (Coleoptera Coccinellidae) on *Citrullus colocynthis* Schrad. (Cucurbitaceae) around the water dam of El Outaya (Biskra, Algeria)

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ABSTRACT

Morphological studies (Total length from apical margin of clypeus to apex of elytra, width, body area and wing length) were carried out on the fourth larval instar, pupa and adult (male and female) of *Henosepilachna elaterii* (Rossi, 1794) (Coleoptera Coccinellidae) sampled from a Cucurbitaceae plant (*Citrullus colocynthis* Schrad.), which grow around the dam "Fountains of Gazelles" in Biskra (Algeria). The fourth instar larva and pupa measured 8.55 ± 0.20 mm and 2.56 ± 0.26 mm; 7.38 ± 0.36 mm and 4.81 ± 0.36 mm; length and width respectively. Adult beetles feeding on fresh leaves were hemi-spherical in shape and red ferruginous in color with 12 black spots on the elytra. Females measured 6.97 ± 0.25 mm in length and 5.37 ± 0.34 mm in width, while males were 6.17 ± 0.31 mm in length and 4.80 ± 0.37 mm in width. Duncan's multiple range tests allowed us to classify specimens in increasing order of area as follows: 4th instar larvae 20.29 ± 0.15 mm^2, adult male 26.41 ± 2.52 mm^2, pupa 28.14±0.31 mm^2 and adult female 31.73 ± 1.84 mm^2. Moreover, the female wing was longer with a value of 10.07 ± 0.54 mm compared to the male, which recorded 8.72 ± 0.60 mm in length. Both adults and larva were serious pests of *Citrullus colocynthis* which resulted in skeletonisation of leaves.

KEY WORDS

Citrullus colocynthis; *Henosepilachna elaterii*; Larvae; Phytophagous.

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INTRODUCTION

Ladybirds (Coleoptera Coccinellidae) are distributed in all the continents, although several authors (Fürsch, 1996; Kovar, 2005) situate them in the tropics and sub-tropics. Others claim that for each continent there is a specific fauna of ladybirds (Belicek, 1976). In Algeria, studies on the biodiversity of ladybirds are very rare. The only reference works that cover the Algerian territory these days are those of Djouhri (1994) and Saharaoui et al. (2014), who are interested in this group of insects by carrying out an inventory in different Algerian agroecosystems.

The family Coccinellidae Latreille, 1807, has about 5000 species spread around the world and it is subdivided into six subfamilies: Chilocorinae, Coccidulinae, Coccinellinae, Epilachninae, Scyminae, Sticholotidinae. Adults are small (1 to 10 mm), hemispherical and brightly colored. Coccinellidae are very close to Endomychidae Leach, 1815, whose larvae live in mushrooms, mainly those of the genus *Lycoperdon* Pers. (Seago et al., 2011). If some genus of Coccidulinae are mycophagous, consuming conidia molds leaves, most are carnivores

feeding on aphids, mealybugs, whiteflies or mites (Bagal & Trehan, 1945).

The Epilachninae are phytophagous and are characterized by multi-serrated mandibles and eyes more distant than the bases of the antennas (Samways et al., 1997). Larvae gnaw on the leaf limb, without perforating it (Bonnemaison, 1962). The sub-family, distributed throughout the planet and well represented in South America, has in Western Europe, some species, including pests, to monitor (Roy et al., 2012).

Considering the relationships that exist between ladybirds phytophagous and the plant species, we carried out surveys and samplings on a plant species of the Cucurbitaceae family (*Citrullus colocynthis* Schrad.) and on the specie of Epilachninae associated with this plant: *Henosepilachna elaterii* (Rossi, 1794).

The ladybird *H. elaterii*, named Melon ladybird beetle or Twelve-spotted melon beetle, has a very beautiful ferruginous red color, a little tawny; the body is entirely covered with a fine golden pubescence (Essig, 1958). In addition, twelve black spots of fairly large size, sometimes welded together (individual variations), are regularly distributed on the elytra; the four previous points are arranged in a straight line (Kaygin & Kaptan, 2017). It is a pest in the Mediterranean Basin, in Corsica and Italy, as well as in North Africa and southern Russia (Bonnemaison, 1962). In Oriental Asia is substituted by *H. pusillanima* (Mulsant, 1850) with the same behavior (Dieke, 1947).

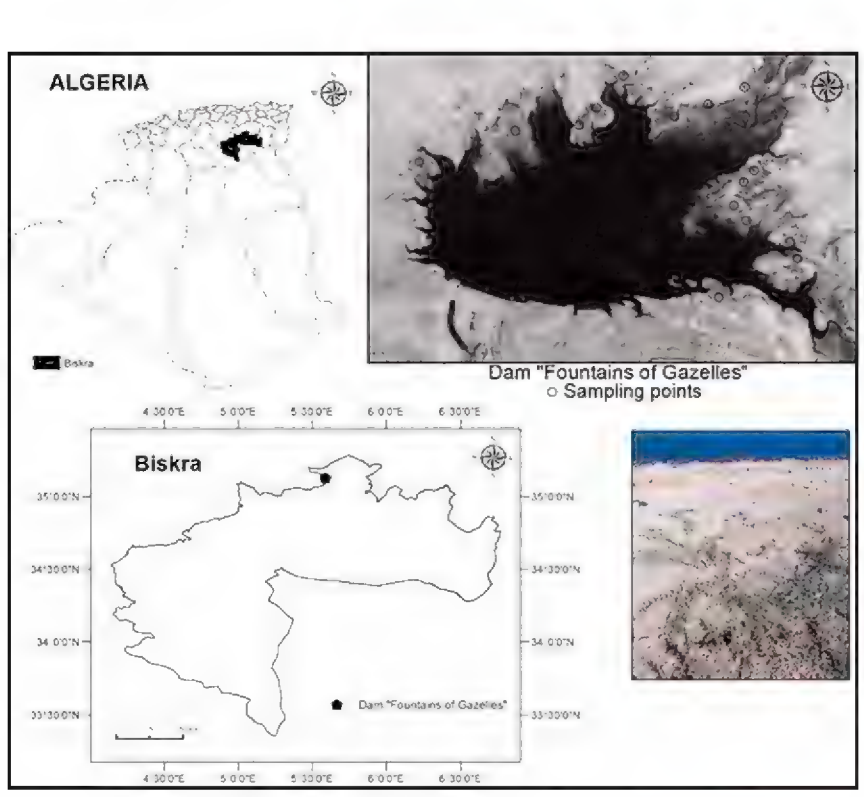

Figure 1. Study area and location of sampling sites (El Outaya, Biskra, Algeria).

The host plants are various cucurbits (Cucurbitaceae), like melons, water melons, snake melons and gourds (Bayhan & Ölmez-Bayhan, 2017). Pupation takes place on the leaf or on rocks. There are 2 to 3 generations per year. Adults overwinter under plant debris until March or April. They gnaw the shoots and then the leaves, under which the females will lay, in packs of 30 to 50, yellow-light eggs, 1.75 to 2 mm in length. Dirty yellow larvae, 8 to 9 mm in size, will hatch a few days later and begin to eat the leaves, leaving bites in parallel (El-Abdin & Siragelnour, 1991).

In this investigation, we will study the morphometry of this species after having evaluate its distribution around the dam "Fontain of Gazelles" in Biskra (Algeria) through several observations and samplings.

MATERIAL AND METHODS

Schematic map and sampling sites

The study on morphometric parameters of a phytophagous coccinellidae species (*H. elaterii*) was carried out at the pedagogic laboratory of the Department of Ecology and Environment, University of Batna 2, Algeria.

To undertake this study, we have made surveys around the dam "Fountains of Gazelles" in Biskra (Algeria) (Latitude: 35°7'48.50"N; Longitude: 5°35'14.07"E; Elevation: 377 m), the surface is about 5 km^2 and the stored water is slightly saline (Fig. 1). Investigations were led during the year 2017, essentially between the beginning of September and the end of November. We adopted the method used by Iperti (1965), which consists in a stratified sampling.

The method used for mapping species distributions corresponds to the real distribution area. Georeferenced distribution maps were realized by GIS software (ArcGIS 10.3). Geographical positions were recorded using a Magellan eXplorist 200 GPS Receiver.

Specimens were sampled from 15 plants of *Citrullus colocynthis*, which grow on the perimeter of the dam and at its proximity up to 10-15 meters (Fig. 1). The specimens of *H. elaterii* were cautio-usly handpicked, placed in Petri dishes and transported to the laboratory to be used in morphological studies.

Morphometry

Twenty specimens from each development stage were used. Morphological studies (total length from apical margin of clypeus to apex of elytra, width, body area and wings length) were carried out on the fourth larval instar, pupa and adult (male and female) of *H. elaterii*. Measurement of wing length has been applied only on adults (male and female). Samples were recorded by photography (using Samsung HD camera ST66, 16.1 megapixels) and measured using Digimizer software (Figs. 2-5). A scale bar was added.

Statistical analysis

The mean length, width and area of all stages of *H. elaterii* (n = 20) were calculated using Excel 2016. The data were statistically treated by Fisher's analysis of variance (ANOVA). Duncan's multiple range tests were performed to determine significant difference between means at a significance level of 5% using Statistical Analysis System software version 9.0 (SAS 2002).

RESULTS AND DISCUSSION

The 4th instar larvae were very active, with black spines all over the body and fed voraciously and their abdomen appeared greenish due to food material inside. The average length and width of 4th instar larvae were (8.55 ± 0.20 mm) and (2.56 ± 0.26 mm) respectively.

Pupa was the non-feeding quiescent stage. It was rectangular and shining yellow with (7.38 ± 0.36 mm) in length and (4.81 ± 0.36 mm) in width, with spines all over the body and bearing last larval skin as pupal case and two anterior black spots then moulted to adult.

Adult beetles feeding on fresh leaves were circular, hemi-spherical in shape and red ferruginous in color with later 12 black spots on the elytra. Females were bigger and darker than males. Indeed, Males were (6.17 ± 0.31 mm) in length and (4.80 ± 0.37 mm) in width. Contrariwise, adult females were (6.97 ± 0.25 mm) in length and (5.37 ± 0.34 mm) in width (Table 1). Moreover, spot areas in adult female were larger with light color perimeter.

Values followed by different letters in the same column are significantly different at $p < 0.05$.

Figures 2, 3. *Citrullus colocynthis* colonized by the 4th larval instar (Fig. 2), and the adult stage of *Henosepilachna elaterii* (Fig. 3). Figures 4, 5. *H. elaterii*: pupa (Fig. 4) and fourth instar larva (Fig. 5). Figure 6. Defoliation on *Citrullus colocynthis* colonized by *H. elaterii.*

Life stage	Body size		
	Length (mm)	Width (mm)	Area (mm^2)
4th larval instar	8.55 ± 0.20^{A}	2.56 ± 0.26^{C}	20.29 ± 0.15^{D}
Pupa	7.38 ± 0.36^{B}	4.81 ± 0.36^{B}	28.14 ± 0.31^{B}
Adult			
Male	6.17 ± 0.31^{C}	4.80 ± 0.37^{B}	26.41 ± 2.52^{C}
Female	6.97 ± 0.25^{D}	5.37 ± 0.34^{A}	31.73 ± 1.84^{A}
p	*<0.0001*	*<0.0001*	*<0.0001*

Table 1. Main results of the ANOVA, sample sizes (Mean ± SD) for each development stage included in this study with Duncan's multiple range tests (n = 20).

For the body area parameter, Duncan's multiple range tests allowed us to classify specimens in increasing order as follows: 4th instar larvae (20.29 ± 0.15 mm^2), adult male (26.41 ± 2.52 mm^2), pupa (28.14 ± 0.31 mm^2) and adult female (31.73 ± 1.84 mm^2) (Table 1).

According to Table 1, the female wing was longer with a value of (10.07 ± 0.54 mm) compared to the male which recorded (8.72 ± 0.60 mm) in length. The pest caused the netting, curling and drying of leaves and the final defoliation (Fig. 6).

The present investigation also shows the consequences that *H. elaterii* made on *C. colocynthis* leaves. Studies on biology and life cycles of *H.*

elaterii on different watermelon cultivars (Bayhan & Ölmez-Bayhan, 2017) have shown similar results in their morphology as observed in the present study, but variations were found in the size of each stage.

Information gathered on life cycle parameters such as duration of the life cycle, size and longevity of each instar, egg laying pattern and nature of the pest is helpful for providing information on population build up, identification of the biotype and their management. Variations observed by different investigators could be attributed to differences in host plant, change in climatic conditions, locality and other environmental factors (Borgia & Miranda, 2016).

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Amphiope caronei n. sp. (Echinoidea Astriclypeidae) from the Tortonian of Cessaniti, Vibo Valentia Province (Calabria, Italy)

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ABSTRACT A new species of *Amphiope* L. Agassiz, 1840 (Echinoidea Astriclypeidae) from the late Miocene (Tortonian) of Vibo Valentia Province, Calabria, Southern Italy, is herein described. This species is distinguished from all the others so far known, by the smaller size of the petalodium, that varies from a minimum of 40.5% to a maximum of 46% (mean 44%) of the test length, thus representing the lowest value in this genus. It is hypothesized that the petalodium reduction could be due to climate and - more generally - environment, resulting from the Mediterranean pre-salinity crisis conditions that characterized these areas during the Tortonian and towards the beginning of the Messinian.

KEY WORDS *Amphiope*; Astriclypeidae; Tortonian, Miocene; Calabria.

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INTRODUCTION

This research aims to improve the definition and taxonomy of the genus *Amphiope* L. Agassiz, 1840 (Echinoidea Astriclypeidae), and to properly reconstruct the Proto-Mediterranean diffusion pathways, thus contributing to a reliable palaeogeographic interpretation. In fact, the diffusion and the taxonomy of *Amphiope* is still partly to be clarified because of the lack of accuracy in the description of the species (rarely concerning the structure) that have been left by several ancient authors (see for example, Agassiz, 1841; Agassiz & Desor, 1847; Cotteau, 1877; 1895; Lambert, 1907, 1912; Comaschi Caria, 1955, 1972; Barbera & Tavernier, 1989). Moreover, Philippe (1998) had put into synonymy of *Amphiope bioculata* (Des Moulins, 1837) many of the previously established nominal species, charging to *Amphiope* a very wide morphological variability. This has led several authors to identify as *A. bioculata*, many forms that have turned out, or that could result, belonging to other species (see also Kroh, 2005; Pereira, 2010; Garilli et al., 2010).

Amphiope is an extinct echinoid genus, belonging to the Astriclypeidae Stefanini, 1912, family, widespread especially in the Proto Western Mediterranean and neighbouring basins during the Miocene (for an overview, see Stara & Rizzo, 2014 and Stara & Borghi, 2017). At the end of the early Miocene, it arrived to Angola, in the South Atlantic, and to North-Western India, in the East (Smith & Kroh, 2011). After Stara & Borghi (2017, with references), the chronological distribution of the species of this genus in the peri-Mediterranean area ranges from the Oligo-Miocene boundary to the Pliocene.

The occurrence of *Amphiope* in the Miocene of Calabria, southern Italy, was previously mentioned by Cottreau (1914) and by Carone & Domning (2007). Carone & Domning (2007) and Marra et al. (2017) have also precisely indicated the stratigra-

phic position of an *Amphiope*-rich level outcropping at Cava Gentile (ex Braunia pro parte), a sand quarry near Cessaniti (Vibo Valentia Province), but none, until now, had described the identifying features of this form of *Amphiope*, classifying them, as proposed by Philippe (1998) as *Amphiope bioculata*. Thanks to a modern approach and using a wide range of measures to study the structure and the morphological and morphometric features of these echinoids, this work propose a new specific systematic classification of these Calabrian's forms. Moreover, once the systematic position has been clarified, finding a link between shape variation and climate change could support, in the future, improved paleoecological interpretations.

Geological setting

The late Miocene succession of Capo Vaticano-Monte Poro extends from the coastal area to the inland of the promontory. It has, in the past, been described in detail by Nicotera (1959) and Rao et al. (2007). Since the late Tortonian, the Capo Vaticano-Monte Poro area acted as a structural high, covered by marine coastal deposits (Fig. 1). The succession overlies the granitic basement and consists of two main intervals (Nicotera, 1959). The lower interval, informally identified as "*dark argillaceous sands with Ostreids and Cerithids*", consists of brackish, organic-rich muds with sandy interfingering deposits, and were interpreted as flood tidal deltas (Neri et al., 2005; Gramigna et al., 2008).

The upper interval, informally named "*Clypeaster* sandstones" ("*Arenarie a* Clypeaster" of Ogniben, 1973), consists of grey sands, several tens of meters thick, and contains an abundance of marine faunas composed by echinoids (mainly *Clypeaster*

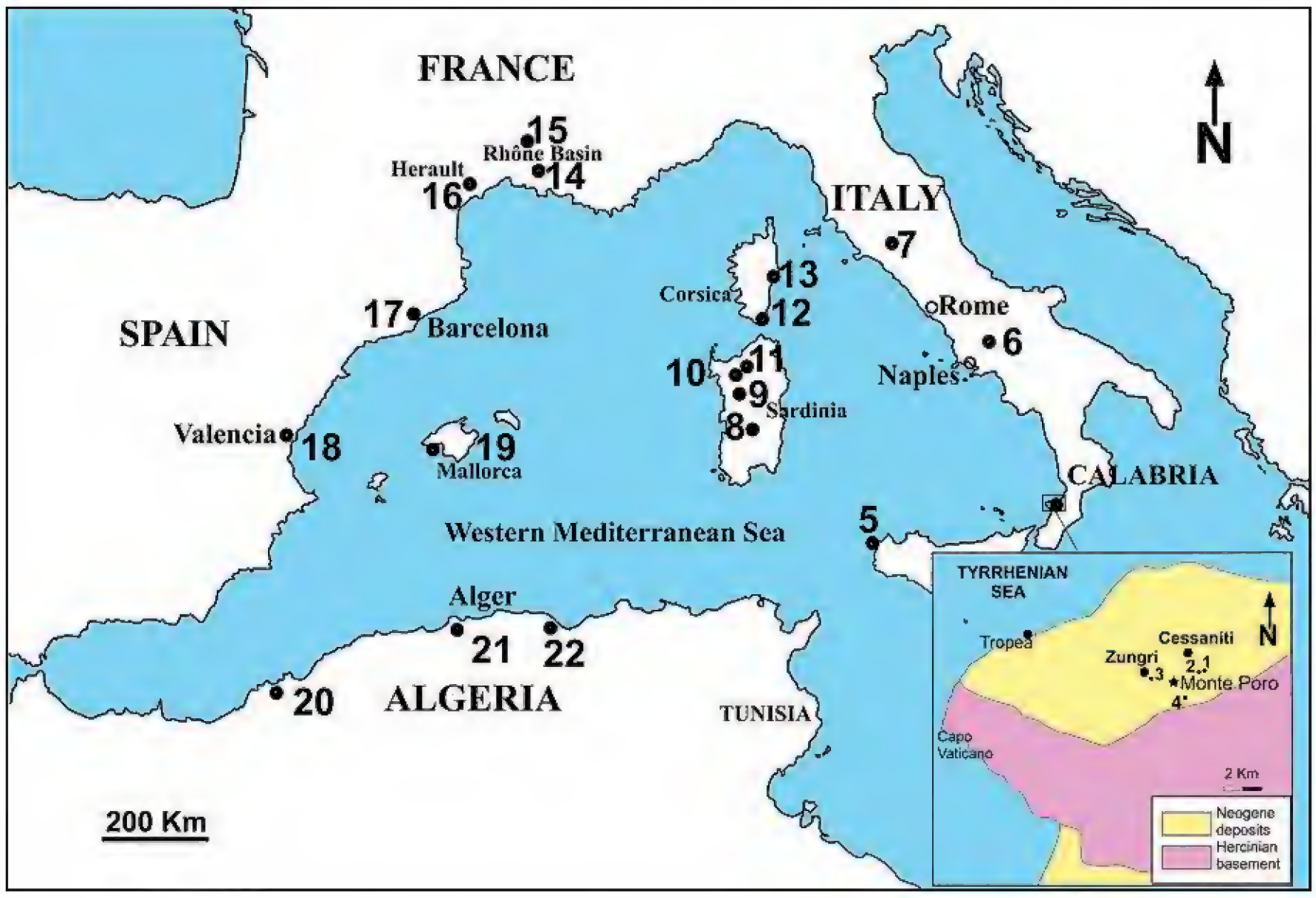


Figure 1: Simplified map of *Amphiope*'s localities cited in, or related to, this study. Italian basins. Calabria: 1 = Cava Gentile; 2 = Cava Franzé; 3 = Papaglionti, loc. Serre; 4 = Zungri. Sicily: 5 = Case Genna (Marsala, Trapani, Tortonian). Campania: 6 = Baselice (Benevento). Latium: 7 = Manciano. Sardinia: 8 = Cuccuru Tuvullau, Nuragus (Cagliari Province); 9 = Bessude and Bonnanaro (Sassari Province); 10 = La Crucca, Bancali and San Giorgio, Western Sassari basin; 11 = Chiaramonti (Sassari Province). France basins. Corsica: 12 = Bonifacio; 13 = Aleria; Rhône Basin: 14 = Cadenet, Vaugines; 15 = Cucuron and Blanqui. Hérault: 16 = Cruzy. Spain basins. 17 = Barcelona; 18 = Valencia; 19 = Mallorca. Algerian basins. 20 = Orano; 21 = Alger; 22 = Tipasa. The Box of Calabria also shows the corresponding geological map (from Marra et al., 2017).

Lamark, 1801), bivalves, fish, and well preserved mammal remains (see also Seguenza, 1880). The "*Clypeaster* sandstones" grade into the "*Heterostegina* yellow sandstones" (Papazzoni & Sirotti, 1999) and in the overlying hemipelagic "*Orbulina* marls" ("Marne a *Orbulina*"; Rao et al., 2007). According to Marra et al. (2017), the main intervals are separated by a ravinement surface (Fig. 2A-C).

Amphiope *in the Cava Gentile section: palaeoenvironmental reconstruction*

As concluded by Marra et al. (2017), the global transgressive trend documented by the succession of the Upper Tortonian in the Capo Vaticano area, showed different local depositional rate of sediment, probably associated with rapid variations in the depositional rate of the sediment and the available storage (accumulation) space (Fig. 2C). The occurrence of alluvial and soil deposits in the Clypeaster sandstones of Cava Gentile, documented by Marra et al. (2017) for the first time, suggested that the late Tortonian transgression was punctuated by minor regression episodes, which caused the abrupt displacements of depositional systems on shallow lagoon and shallow marine environments (Fig. 2). The subsequent increase in the sea level led to the accumulation of sea and land fossils together in certain transgressive horizons. Therefore, the "*Clypeaster* sandstones", which are well-known and well-studied thanks to the presence of an abundant well-preserved fauna, are ascribed to a shallow-water and wave-dominated marine depositional environment (Carone & Domning, 2007; Gramigna et al., 2008), interspersed by short regressive periods, resulting in changes in the depositional environment (Marra et al., 2017). The marine fauna represented in these sands consists of echinoids (especially well preserved *Clypeaster* and also, to a lesser extent, *Amphiope*, echinolampadids, hypsoclypeids and spatangoids), bivalves and rare gastropods (both of these usually preserved as internal moulds), marine fish and mammals (especially sirenians). The terrestrial fauna is represented by bovids, proboscideans, and giraffids (Carone & Domning, 2007; Gramigna et al., 2008; Marra et al., 2017).

In this context, the fossil specimens of *Amphiope* lie just above the ravinement surfaces, corresponding to the closest part to the shore line, into metric levels of conglomerates with pebbles up to 3–4 cm (Fig. 3), or sands accompanied by pebbles, with rare fragments of *Clypeaster* and scarce internal moulds of indeterminable bivalves. This interpretation is valid for the section under consideration, but it may differ in thicknesses and facies at the other *Amphiope*-bearing sites. However, the facies in which *Amphiope* remains was ob-

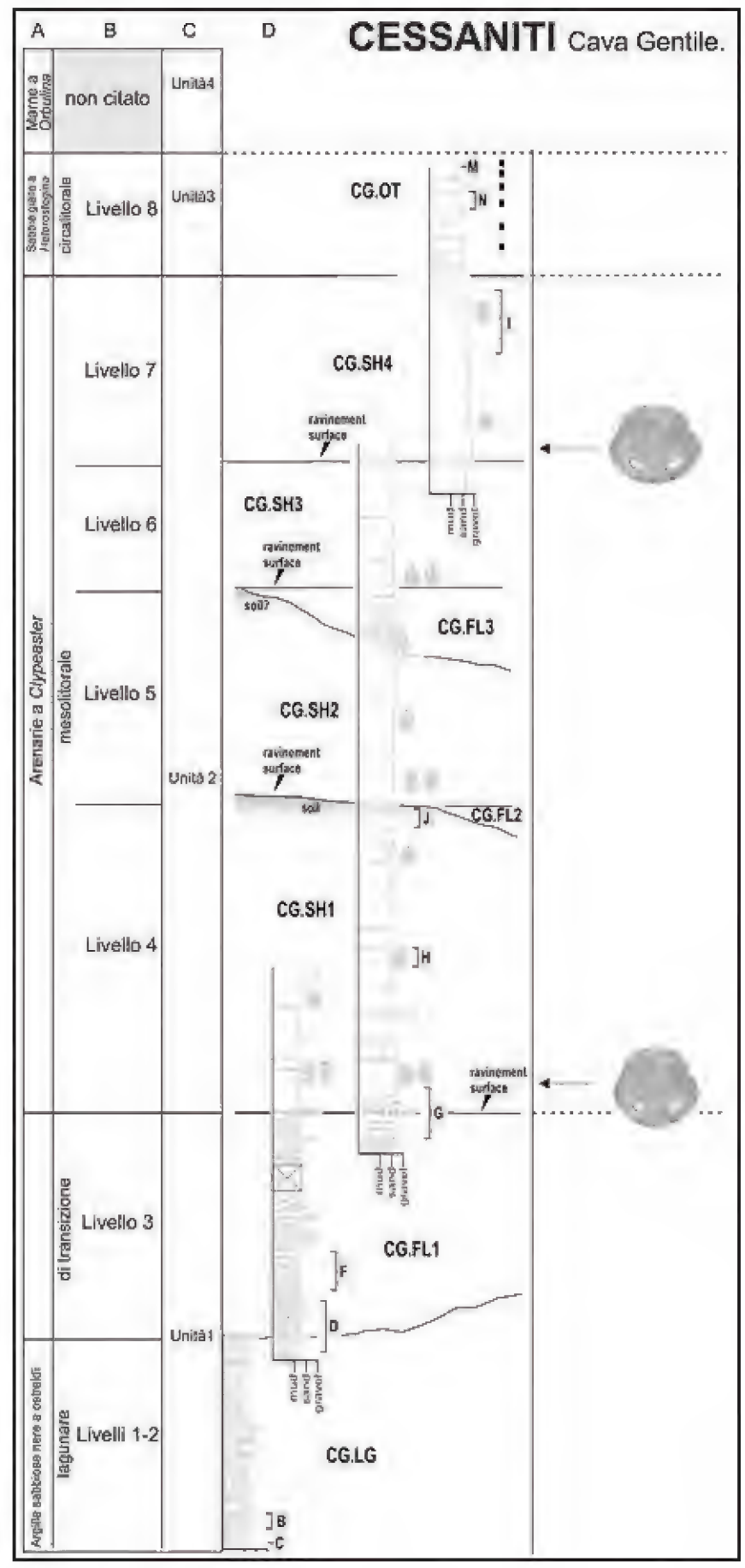


Figure 2. Stratigraphic Columns showing the successions at Quarry Cava Gentile, according to units reported by: (A) Nicotera, 1959; Ogniben, 1973; Rao et al., 2007; (B) Carone & Domning, 2007; (C) Gramigna et al., 2008; (D) Marra et al., 2017.

served (Cava Franzé, Papaglionti and Zungri), differ only slightly from those documented at the Cava Gentile.

The fossils remains of *Amphiope* are generally scattered, and show a random position, rarely they are found in life position or with different inclinations, and sometimes they are overthrown but apparently consistent with the stratification (Fig. 3). Furthermore, the *Amphiope* test remains consistently appear to show the surface indented by sandstone grains and show no evidence of parasites and/or epibionts attacks, nor evidence of post-mortem erosion by transport, but rather they often display a fragmentation of the tests which we interpret as caused by the remixing of the sediment in a wave dominated environment. In this area, the density of *Amphiope* remains is very low, with a maximum of five-six individuals per square meter. The outcrops are only five meters long and as of yet, no mass accumulation cases have been observed.

Palaeoecology

Variations in the climate occurred from the Oligocene end to the late Miocene (late Tortonian-Middle Messinian); this includes an increase in the average temperature, which reached its peak with the establishment of the Climate Optimum of the late Burdigalian-middle Langhian (Kroh, 2007; Popescu, 2009). The Climate Optimum was followed by a negative trend lasting until the end of the Miocene. In fact, from the Langhian to the Messinian Salinity Crisis, there had been a continuous decrease in the average temperature and an increase in seasonality (Popescu, 2009). Consequently, there had been a shift towards the south of the tropical-subtropical climate that had previously characterized the entire basin of the Western Proto-Mediterranean Sea, its peri-Mediterranean basins (Lauriat-Rage et al., 1993; Kroh, 2007; Popescu, 2009), and its related terrestrial environments (Kürschner et al., 2008).

According to Carone & Domning (2007) the reduced size of Sirenia that populated the marine environment along the Calabro-Peloritan Arc during the late Tortonian-early Messinian was due to deteriorated ecological conditions. Another evidence of the climatic cooling after the Miocene Climate Optimum is given by Popescu (2009), who observed the climate change by comparison of the northern mangrove populations, which first retreated from the French coast, then from the Spanish ones, and survived only along the North African coasts in the late Miocene.

According to Stara et al. (2015) and Stara & Borghi (2017), climate cooling seem associated in *Amphiope* with a progressive decrease in the size of the lunules, documented e.g., in some populations of the Serravallian-Tortonian of Herault, France (Stara & Borghi, 2017); Late Tortonian of Calabria (this work); Tortonian of Valencia, Spain (Stara et al., 2015) and Pliocene of Tipasa, Algeria (Aymé & Roman, 1954).

Finally, Gramigna et al. (2012) also observed that in the late Tortonian-early Messinian age, the marginal areas of Calabria (e.g., the Capo Vaticano-Monte Poro area, where the *Amphiope* population under study dwelled), were characterized by the development of siliciclastic-carbonate temperate ramps and that the absence of non-skeletal grains (ooids and green algae), the scanty presence of Porites coral reefs, and the rare occurrence of primary marine cementation, confirm that these ramps were poorly lithified in a warm-tempered environment.

Figure 3. Conglomerate level with *Amphiope* at the Franzé quarry.

MATERIAL AND METHODS

Study area

The fossils found in Calabria were collected

from four localities (Figure 1): Cava Gentile quarry; Cava Franzé quarry (both in the Cessaniti Municipality); "Zungri" outcrop, at the periphery of the Zungri village; Serre locality outcrop, near Papaglionti village (Zungri Municipality). The Zungri and Papaglionti outcrops are quite small, only a few square meters, and the vegetation surrounding them did not allow us to detect, to any certainty, a stratigraphic section. The Cava Gentile and the Cava Franzé localities, on the other hand, were two large excavations with separate accesses, located in the same hill. According to Gramigna et al. (2012), the stratigraphic sequence throughout the Cessaniti-Monte Poro area is homogeneous, albeit with different thicknesses. For this, as was done by Gramigna et al (2008), Carone & Domning (2007), and Marra et al. (2017), the most complete and best exposed section of Cava Gentile (Fig. 2) is here taken as reference for the whole area. The specimens collected in Cava Franzé come from two levels corresponding to those of Cava Gentile.

Material

Twenty-six whole specimens and various fragments of *Amphiope*, collected in June 2013, are here examined: six, plus some fragments, from Papaglionti, five from Cava Gentile, thirteen from the Cava Franzé and one, plus some fragments, from Zungri. The data from these specimens was compared with those of other species of *Amphiope*, as reported in the graphs; other measures and statistics were taken from illustrations reported in the literature. Additional data on French, Algerian, and Italian related species, used for comparisons, were taken from Stara & Borghi (2017).

Methods

To highlight the sutures lines, the specimens have been humidificated by a mixture of water and hydrochloric acid (ca. 2%) and finally the washed surfaces were moistened with vaseline based cream. The internal structure was studied by sectioning the test subject and in some cases by X-ray analysis. To simplify the comparison, we divided the *Amphiope* species into two informal groups, as proposed by Stara et al. (2015). The first, called the "*A. bioculata*" group, were characterised by roundish to broad elliptical lunules with major/minor diameter ratios (SI) ≤ 1.6, and the "*A. nuragica*" group, consistent of mainly narrow lunules and ratios of SI > 1.6. Since all the specimens examined on behalf of this paper belong to the *A. nuragica* group, we have thus analysed only the differences among the species included in these particular species. To make the comparative diagrams, we used the statistic program of Hammer Ø., 2014. PAST 3.2. Numbering in plate drawings is based upon the Lovén (1874) system, and interambulacra are shaded in grey. Systematic palaeontology follows Kroh & Smith (2010), Smith & Kroh (2011), Stara & Borghi (2017), and Kroh & Mooi (2018). Geographic coordinates are provided in WGS84.

ABBREVIATIONS AND ACRONYMS. Morphological abbreviations as in Figure 4 and Table 1 (pro parte): TL = test length; TW = test width; TH = test height; L1-L2 = lunule length and width, respectively; L3 = distance between posterior petal-tip and lunule, L4 = distance between apical system and posterior margin, L5-L6 = length and width of the frontal petal, respectively; L7-L8 = length and width of the anterior paired petals, respectively; L9-L10 = length and width of the posterior petals, respectively; L11 = distance between posterior border of the periproct and posterior margin test; L12 = distance between the posterior border of the peristome and the border of the periproct, L13 = front-rear diameter of the ambulacral basicoronal circlet. PL = petalodium length; ø pc = periproct diameter; ø ps = peristome diameter. To describe the lunules shape and dimension into a numeric value, we use a SI (Shape Index) corresponding to the ratio L2/L1 and a WI (Width Index) = (L1 x L2) corresponding the area inscribing the lunule, as done by Stara & Borghi (2017).

Institutions abbreviation: MP.CM.UNINA (Museo di Paleontologia, Centro Museale Università Federico II, Napoli, Italy); MURI (Museo di Ricadi, Vibo Valentia Province, Italy); MAC (Museo di Storia Naturale Aquilegia, Masullas, Oristano province, Italy); MNHN-F (Muséum National d' Histoire Naturelle of Paris, France).

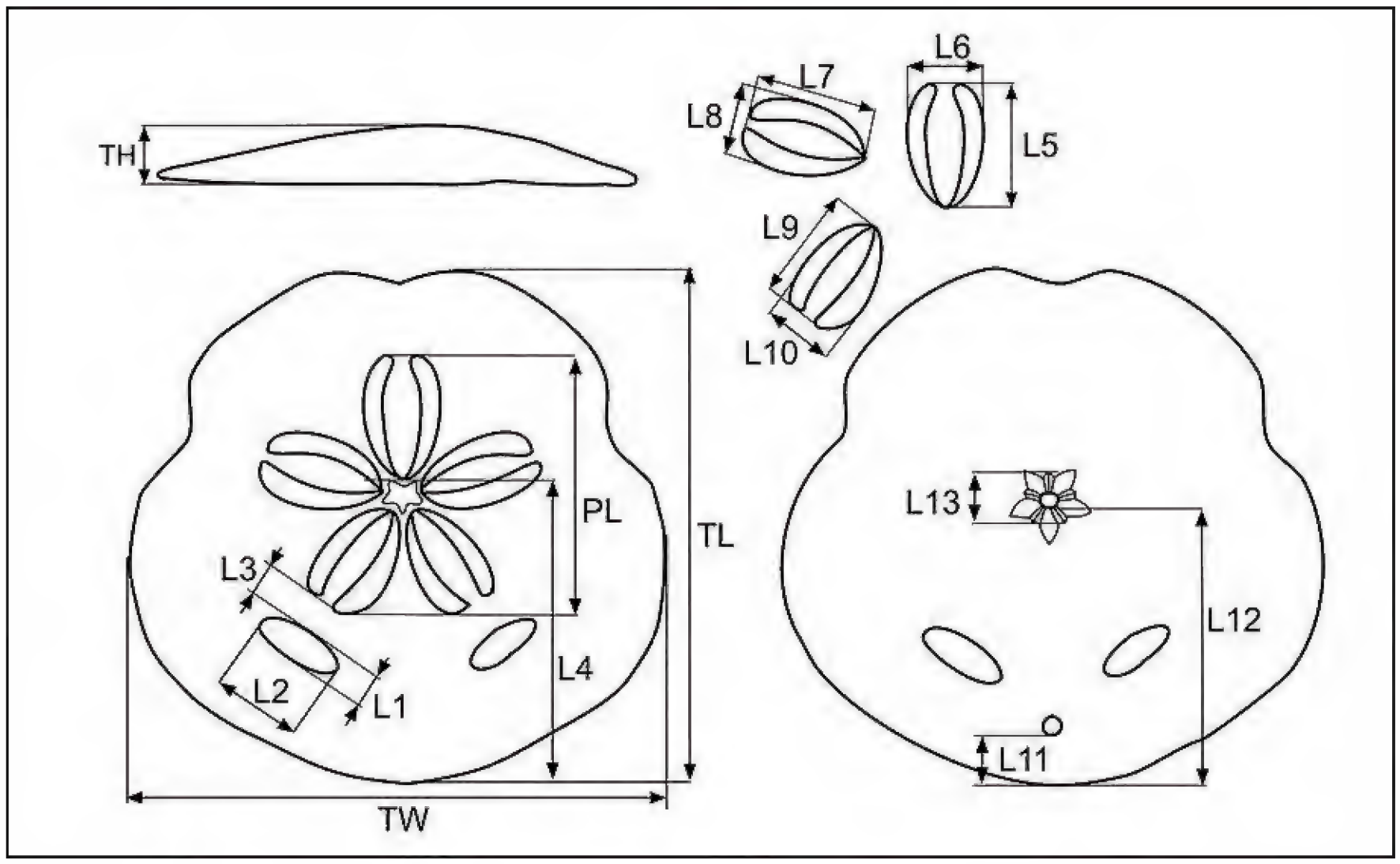


Figure 4. Biometric parameters utilised in the studied samples.

RESULTS

Compared with all those known so far, the specimens under study shows very small lunules (mean WI = 80), but also the smallest petalodium within this genus (see Figure 5): in fact, the petalodium length range from 40.5% of TL to 46% of TL, contrary to a range known for this genus that spans from 44% to 62% of TL (Stara & Borghi, 2017). The total number of specimens (Twenty-six whole specimens and various fragments) allows us to consider this sample valid for a correct specific systematic classification. In this group of specimens, two morphotypes are distinguishable, by a slightly different robustness of the structure and by a slightly different plates schemes on the oral face within the interambulacrum 5, as detailed in the discussion and systematic chapter. However, since the X-rays analysis performed on these two forms does not show substantial differences (Figs. 12, 13), we decided to include both morphotypes in a single species. By comparison, these specimens are different from all forms so far known in the *A. nuragica* group and represents a new species, for which the name *Amphiope caronei* n. sp. is here proposed.

DISCUSSION

Amphiope is a genus adapted to a tropical climate (Nebelsick & Kroh, 2002; Smith & Kroh, 2011; Stara et al., 2012; Mancosu & Nebelsick, 2013, Stara & Borghi, 2014; Stara & Sanciu, 2014; Mancosu & Nebelsick, 2015). Consequently, the temperate environment type, inhabited by the studied populations (Gramigna et al., 2012), was not ideal for them and substantial evidence suggests that they had undergone adaptation processes. As noted by Stara & Borghi (2014), important changes in the structure of *Amphiope* have occurred during the Oligo-Miocene. Together with a reduction of the overall structure (thickness of internal reinforcement and extension of visceral spaces), there has been a decrease in the number of plates, in particular in the interambulacrum 5; this varied from 16–20 plates in *Amphiope nuragica* (Comaschi Caria, 1955), from the Chattian-Aquitanian of Cuccuru Tuvullau (Sardinia, Italy), to 10–11 in *Amphiope deydieri* Lambert, 1912, from the Serravallian of Vaugines (Vaucluse, France).

However, while these structural changes did not appear clearly to be directly related to the va-

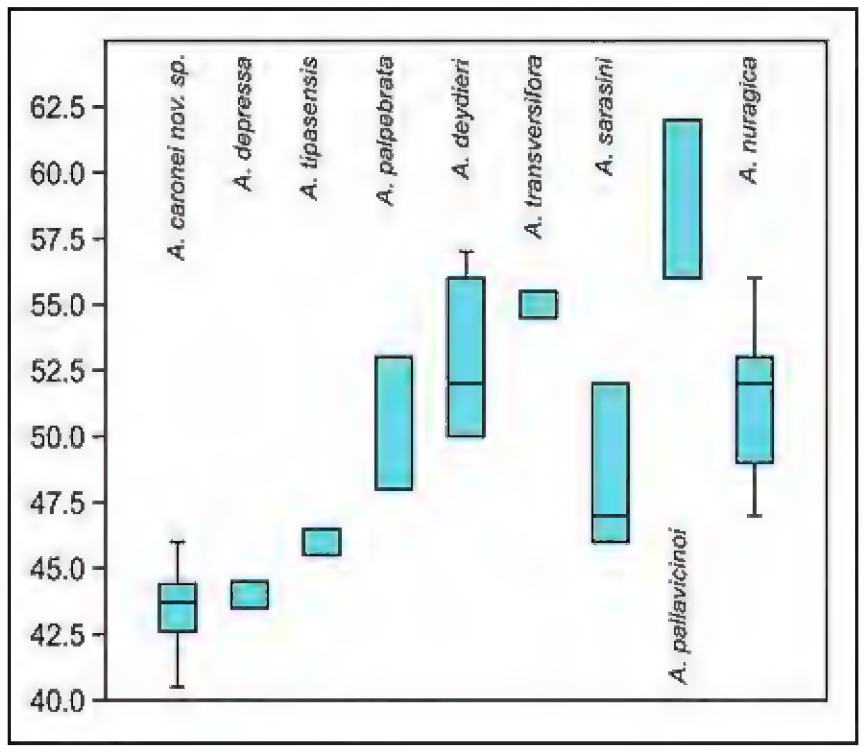


Figure 5. PL comparison between *Amphiope caronei* n. sp. and the others species included in the informal *nuragica* group (except *A. hollandei*).

riation of environmental conditions, other changes seem correlated to the climate-ecological changes. In fact, the *Amphiope* populations considered in this study, share some peculiarities with other contemporary populations of *Amphiope* in the Proto-Mediterranean regions, during the period starting from the middle-late Miocene up to the Pliocene: *Amphiope* sp. from La Crucca, Sassari Province, Sardinia, Italy (in Stara et al., 2012; Langhian-early Serravallian in age, after Carboni & Kotsakis, 1983); *Amphiope sarasini* Lambert, 1907 from the Rhône Basin, SE France (Serravallian-Tortonian); *Amphiope* sp. from Valencia (in Stara et al., 2015), Spain (Tortonian); *A. depressa* Pomel, 1887, from Orano Region, NW Algeria (prob. Tortonian); *A. tipasensis* (Roman in Aymé & Roman, 1954) from Tipasa Province, Northern Algeria (Pliocene) (in Stara & Borghi, 2017). For a complete review of the function and dimension of the lunules, we refer to the reader the work of Mancosu & Nebelsick (2015), in which the different theses published over the time by previous authors on this topic are compared. However, after our observations, these peculiarities appear to be linked to the deterioration of the climatic and ecological conditions occurring in the Proto-Mediterranean Basin toward the late Miocene.

Lunule and petalodium size

The characteristics of the different *Amphiope* morphotypes that lived in the peri-Mediterranean Basin, provided to us by previous studies, allow us to bring some observations. The size of the lunules has considerably increased during the Middle Miocene Climate Optimum, then slowly diminished, reaching its minimum during the Serravallian-Tortonian and the Pliocene.

Some examples of morphotypes with large lunules are the *Amphiope* sp. 2 from Bancali and *A. montezemoloi* from San Giorgio, Sardinia, both from the late Burdigalian-Early Langhian (Stara & Borghi, 2014; Mancosu & Nebelsick, 2015), "*A. montezemoloi*" from Middle Miocene of La Sequita, Tarragona, Barcelona Region, Spain (Lambert, 1928) and "*A. montezemoloi*" from the Burdigalian of Sidi Aïch, Vallée de la Soummam, Algeria (specimens MNHN-F R67289a-b). It should also be noted that at times, the test size had increased simultaneously to the growth of the lunules, as is *Amphiope* sp. 2 from the upper Burdigalian of Bancali (in Stara & Borghi, 2014; Mancosu & Nabelsick, 2015), in which the test subject rose to 170 mm of TL., the maximum size known in this genus.

Concerning the specimens from Calabria, a significant decrease in the petalodium size accompanies the decrease in size of the lunules. This suggest (but further studies need) a structural adjustment resulting from the deterioration of the ecological conditions, even if we do not know the mechanisms that may have modulated these characters.

Variation in plate number and shape

Observations and analysis carried out by Stara & Borghi (2014) while studying variations in the plating pathways in *Amphiope*, found that the number of plates lowered along the geologic times. The number of plates, which was 16–20 in *A. nuragica* (Chattian-Aquitanian in age), both in the interambulacrum 5, and in the ambulacra I and V, was found much lower in *A. lovisatoi* (Late Burdigalian in age). In fact, in this species, the plate numbers was only 13–14 (in the interambulacrum 5) and 15–16 (in the ambulacra I and V).

A substantial numerical change was also observed in the oral interambulacrum 5 plate scheme of these two species: a drop in the number of plates from 3–4 to 2–3 in column "a" and from 4 to 3 in column "b", respectively.

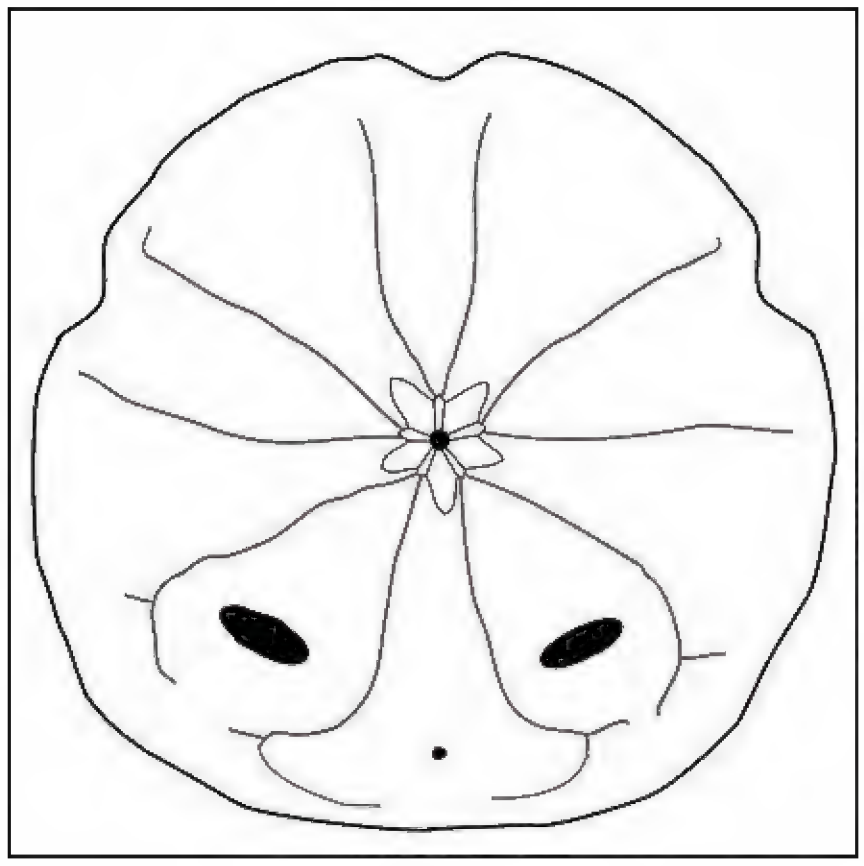


Figure 6. Food grooves schema in *Amphiope* specimen from Gentile Quarry.

Also, in the specimens collected from Calabria there were a low number of plates: 13–14 in the interambulacrum 5 and 15/17 per column in the ambulacra I and V, together with a simplification in the plating scheme of the oral part of the interambulacrum 5, with only 2 plates in column "a" and 2–3 in column "b". In particular, in some specimens from Papaglionti (Figs. 14–17), the first ambulacral post-basicoronal plates (I.2.b and V.2.a), that occlude the interambulacrum 5, appear to complete their development late during growth.

At the same time, however, the plates of the interambulacrum 5 have already reached their maximum size and their number does not increase, at least in the considered sample.

SYSTEMATIC PALAEONTOLOGY

Family ASTRICLYPEIDAE Stefanini, 1912

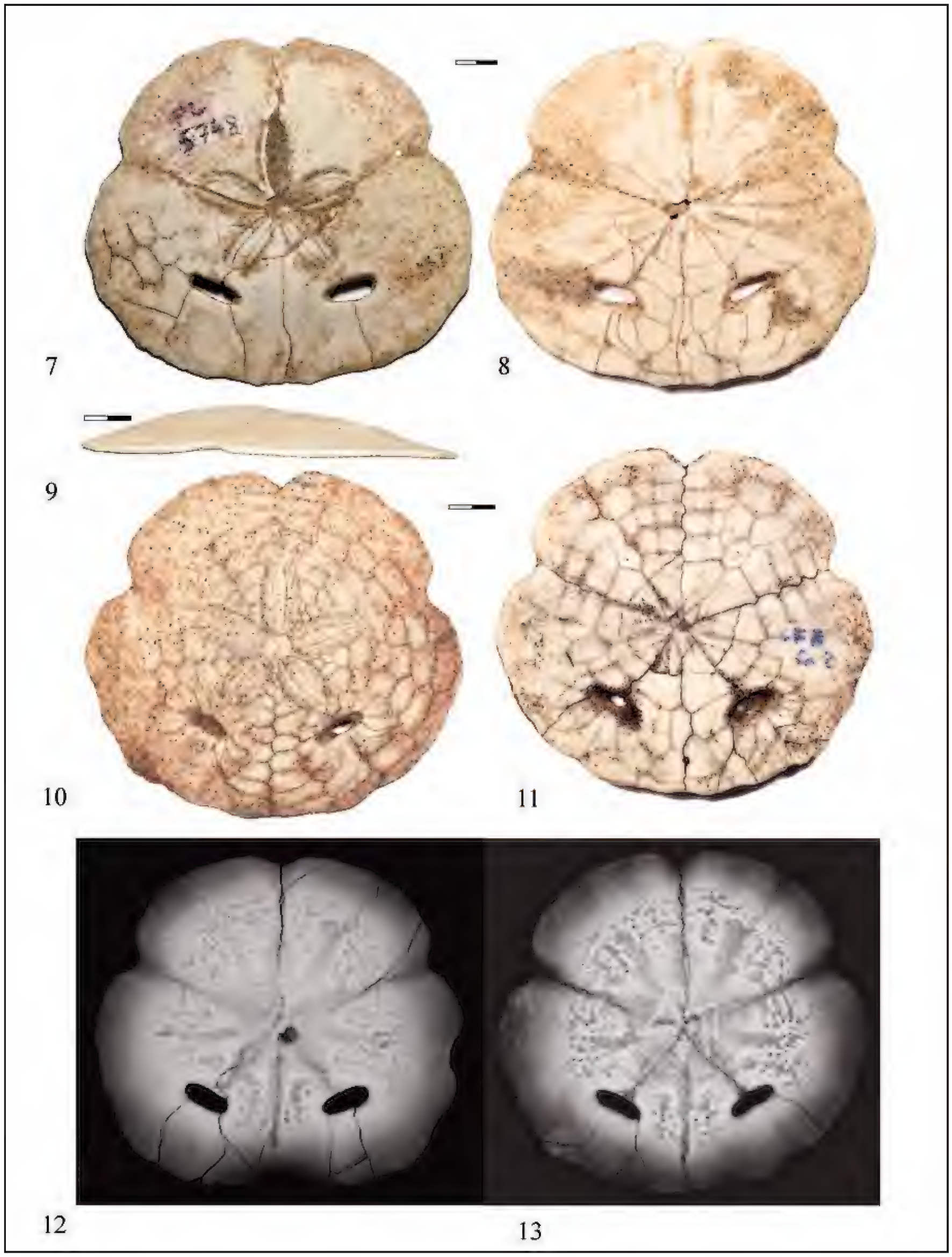
Genera included: *Amphiope* L. Agassiz, 1840; *Paraamphiope* Stara et Sanciu, 2014; *Sculpsitechinus* Stara et Sanciu, 2014; *Echinodiscus* Leske, 1778; *Astriclypeus* Verril, 1867

Genus *Amphiope* L. Agassiz, 1840

Type species. *Scutella bioculata* Des Moulins, 1837, by subsequent designation of Lambert (1907, p. 49).

EMENDED DIAGNOSIS. Partially modified from Smith & Kroh (2011) and Stara & Borghi (2017).

- Test low with sharp margin.
- Internal support well developed, consisting of pillars and walls crossed by cavities.
- Peripheral ballast system may be very dense and crossed by micro-canals, towards the ambitus.
- Apical disc monobasal, sub-central, with four gonopores.
- Petals well developed; short (PL range from 40.5 to 61% TL) and closed distally; generally, all five petals similar in length, sometimes the anterior slightly longer or the posterior slightly shorter.
- Lunules rounded, largely ovate transverse (rarely ovate axial), narrow ovate or slit-like transverse, present in the posterior ambulacra.
- Oral side flat or slightly concave.
- Oral interambulacra narrower than the ambulacra, even at their widest point. Oral interambulacra 1, 4 and 5 always with only the first postbasicoronal plate 5.b.2 in contact with the first pair of ambulacral plates; the interambulacral zones are separated by a couple of enlarged first postbasicoronal ambulacral plates. Interambulacra 2 and 3 may have only the plate 5.2.b, or both plates 5.2.b and 5.2.a, in contact with the two adjacent ambulacral postbasicoronals.
- Basicoronal circlet pentastellate with interambulacral plates forming the points.
- Peristome small, subcentral.
- Periproct circular, small, opening between the first, the second, or the third pair of post-basicoronal interambulacral plates. Two to five postbasicoronal plates present in the interambulacrum 5 adorally.
- Food grooves simple (more complex in *A. sarasini*), bifurcating at the edge of the basicoronal plate; they do not reach the margin. Posterior pair of food grooves running around the lunules.
- Ambulacra a little wider than interambulacra at ambitus.
- Tuberculation dense, made of very small, perforate and crenulate tubercles, larger on the oral face than aborally.



Figures 7–9, MP.CM.UNINA5748 from Papaglionti: aboral, oral, and lateral views, respectively. Figures 10–11: MP.CM.UNINA 5749 from Cava Franzé. Figures 12–13: radiographs of MP.CM.UNINA5748 and MP.CM.UNINA5749, respectively.

DISTRIBUTION. Oligo-Miocene of Sardinia; Miocene of Europe, Northern and Western Africa, Middle East and Northern India; Pliocene of Algeria.

Species included (from Stara & Borghi, 2017):

Amphiope bioculata - (Des Moulins, 1837), Langhian-Serravallian, Hérault (France)
A. elliptica - Desor, 1847, late Aquitanian, Bouche du Rhône (France)
A. hollandei - Cotteau, 1877, Burdigalian, Corsica (France)
A. depressa - Pomel, 1887, middle Miocene, Algeria
A. palpebrata - Pomel, 1887, Miocene, Algeria
A. lovisatoi - Cotteau, 1895, late Burdigalian, Sardinia (Italy)
A. neuparthi - de Loriol, 1905, ?Burdigalian, Luanda (Angola)
A. lorioli - Lambert, 1907, Tortonian, Hérault (France)
A. sarasini - Lambert, 1907, Serravallian-Tortonian, Hérault (France)
A. transversifora - Lambert, 1910, Langhian, Drôme (France)
A. montezemoloi - Lovisato, 1911, late Burdigalian-early Langhian, Sardinia (Italy)
A. ludovici - Lambert, 1912, Tortonian, Vaucluse (France)
A. deydieri - Lambert, 1912, Serravallian, Vaucluse (France)
A. pallavicinoi - Lovisato, 1914, late Burdigalian, Sardinia (Italy)
A. tipasensis - (Roman, in Aymé & Roman, 1954), Pliocene, Algeria
A. nuragica - (Comaschi Caria, 1955), late Chattian-early Aquitanian, Sardinia (Italy)
A. romani - Stara & Borghi, 2017, Serravallian - Tortonian, Touraine (France)
A. caronei n. sp. - Tortonian, Vibo Valentia Province, Calabria (Italy)

Other species were described in the literature, but they need re-discussion by modern approach (from Smith & Kroh, 2011; Stara & Sanciu, 2014; Stara & Borghi, 2017).

The informal *A. nuragica* group includes: *A. hollandei*, *A. depressa*, *A. palpebrata*, *A. sarasini*, *A. transversifora*, *A. deydieri*, *A. pallavicinoi*, *A. tipasensis*, *A. nuragica* and *A. caronei* n. sp.

Amphiope caronei n. sp. Figs. 7–19, Table 1

Amphiope bioculata - Cottreau, 1914: 31
A. biauriculata - Carone & Domning, 2007: 60
A. sp. - Stara et al., 2015: 396

TYPE MATERIAL. Holotype: a complete specimen housed in MP.CM.UNINA 5748. Main data in Table 1; Paratypes: MP.CM.UNINA 5749–55; MURI GPT 105(ces)E4, MURI GPT 117(ces)E4, MURI GPT 113(pap)E1; MAC PL 1728.

TYPE AREA. Monte Poro: includes Cava Gentile and Cava Franzé quarries (38°39'02.42"N, 16°02'01.57"E); Papaglionti, Serre locality near Zungri (36°39'29.39"N, 16°01'06.85"E) and Zungri village outcrops. Vibo Valentia Province, Calabria (Italy).

TYPE STRATUM. Conglomerate made up of mostly granodioritic pebbles together with *Amphiope* fossils remains in the Unit 2, Gramigna et al., 2008; Levels 4 and 7, Carone & Domning, 2007; or CG.SH1 and CG.SH4, after Marra et al., 2017, at the Cava Gentile, all into the informal "Arenarie a *Clypeaster* formation", Nicotera, 1959.

EXAMINED MATERIAL. The studied sample from the type area consists of 24 whole tests (code: MP.CM.UNINA 5748-54; MURI GPT 105–112(ces)E4, 116-117(ces)E4, 118(ces)E7, 113–115(pap)E1; MAC PL 1728, MAC PL-1475–7 and two test fragments (MP.CM.UNINA 5755).

ETYMOLOGY. In honour of the Italian palaeontologist Giuseppe Carone, founder of the MURI, "Paleontological Ricadi Museum" (Vibo Valentia Province), Italy.

DIAGNOSIS. Species of *Amphiope* with small petalodium (minimum PL = 40.5% TL, mean PL = 44% TL) and with small (mean WI=80), narrow and slit-like transverse lunules.

DESCRIPTION. Medium sized individuals (maximum value in our sample, TL = 94 mm), usually a bit wider than long (mean TW = 107% TL); narrower anteriorly, with large inflections in the margin, at the end of the ambulacra II, III and IV; rounded rear. Depressed shape (mean TH = 11% TL), with rounded margins (1.8–2 mm). Apex middle-sized (8% TL) and centrally positioned.

Internal structure: in the radiograph, the central hollow vary from sub-pentagonal to star-shaped (Figs. 12, 13), the antero-posterior length equals the length of the petalodium. The internal support system is well-articulated and light around the central hollow, but it becomes very dense toward the ambitus.

From the central hollow, five cavities branch off along the interambulacra; the widest is located along the interambulacrum 2, while the longer leads to the periproct, along the interambulacrum 5.

The Aristotle lantern is wide; a reconstruction shows that it measures, in antero-posterior direction, about 22% TL.

Oral face flat, with slight inflections along the ambulacra.

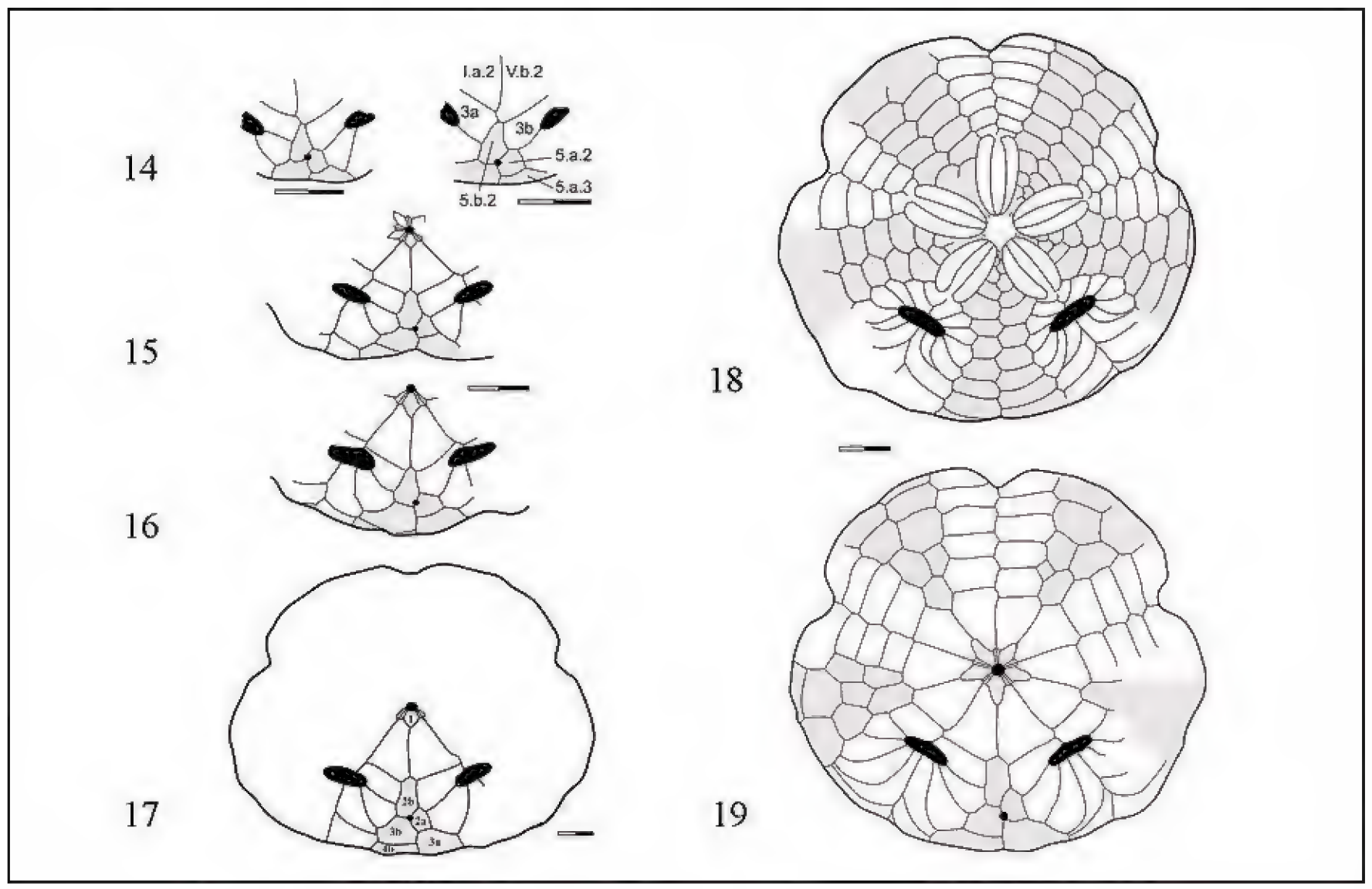
Petalodium small (range from 40.5 to 46 % TL, mean PL = 44% TL); petals closed, sub-equal, the posterior paired petals slightly shorter (mean L5 and L7=21% TL; mean L9=18% TL); all of equivalent width. Ratio between the width of the poriferous and interporiferous areas highly variable (Figs. 7–10).

Lunules always small (mean WI = 80), long and narrow (mean SI = 2.9), like linear slits. Lunules open at about one third of the distance petal - posterior margin; the distance between the tip of posterior petals and the corresponding lunules (L3= 6% TL) is occupied always by two plates per column.

In the oral interambulacrum 5, column "a" is made of 2 post-basicoronal plates, column "b" of 2–3 plates. The basicoronal interambulacral plate 5.1 is short (about 6-8% TL). On the whole, there are 13–14 plates per column in the interambulacrum 5, 13–14 in the ambulacra III and 15–16/17 in the ambulacra I and V.

Stoma small (1.8–3.4% TL), rounded, with prominences in correspondence of the interambulacra, central (mean L12=48% TL).

Periproct small (mean 2.5% TL), rounded, next to the rear margin (mean L11 = 9% TL), open between plates 5.b.2-5.a.2-5.b.3. (seven specimens), 5.a.2-



Figures 14–17. Partial plating schemes in specimens from Papaglionti outcrop: Figures 14–16. Relationship of / modifications between plates 5.b.2 and the first post-basicoronal plates I.b.2 and V.a.2 during growth; Figure 17, MP.CM.UNINA5748, showing the Loven's numbering and periproct position in interambulacrum 5. Figures 18, 19, aboral and oral plating schemes, respectively, of MP.CM.UNINA5749 from Franzé Quarry.

5.b.3 (six specimens) or 5.a.2-5.b.3-5.a.3 (three specimens).

Food-grooves generally not well visible; only a single specimen collected from Cava Gentile and some fragments from Cava Franzé, not indented by sand grains, enabled to draw the food grooves scheme, shown in Figure 5.

Tuberculation poorly evident, due to the indentation of the granules of sandstone on the test surfaces and by the fossilisation processes.

OCCURRENCE. Cava Gentile and Cava Franzé quarries near Cessaniti, Papaglionti and Zungri (Vibo Valentia Province, Calabria), late Tortonian.

REMARKS. All the samples examined belong to the informal *A. nuragica* group, and then comparison will be limited to the species belonging to this group.

Amphiope caronei n. sp. differs from: *A. hollandei*, *A. sarasini*, *A. transversifora*, *A. deydieri*, *A. palpebrata*, and *A. nuragica*, mainly by the smaller petalodium (mean 44% TL against 54%, 49%, 55%, 53%, 52%, 53% TL, respectively) (see also Fig. 5, pro parte).

Additionally, *A. caronei* n. sp. differs from these species by other characters, shown in figure 20 (WI comparison) and figure 21 (SI comparison, pro parte). Data taken from Stara et al. (2015) and Stara & Borghi (2017).

Amphiope hollandei and *A. deydieri* have also the widest test (TW=120% and 122% TL, respectively, against to an average of 107% TL in *A. caronei* n. sp.). *Amphiope hollandei* also has the lunules with SI = 7 against 2.9 of *A. caronei* n. sp., while *A. deydieri* has WI=135 against 80 of *A. caronei* n. sp.

Amphiope transversifora differs from *A. caronei*, also in having a higher WI (148 versus 80) and a lower number of plates, both in the interambulacrum 5 (12–13 against 13–14), than in the ambulacrum I and V (13–14 against 15-17).

Amphiope caronei n. sp. differs from *A. palpebrata* also by a different internal structure; in fact, *A. palpebrata* has a much lighter system of internal supports, with wider central cavity, which extends almost to the margin.

Different results are provided by the comparison with *Amphiope depressa* Pomel, 1887 and *A. tipasensis* from Algeria. The first species is known only by the original illustration (Pomel, 1887: plate XII, figures 1a-c), but the author himself stated that in reality, the illustrated specimen had a part of the posterior margin missing; moreover, in the drawing the plating scheme was not reported, consequently it is not completely comparable with other species. According to the available data we can say that *A. depressa* differs from *A. caronei* n. sp. in having (o by) smaller lunules (WI = 46 versus 80), and with a lower SI (1.8 against 2.9). *Amphiope tipasensis* has lunules similar to those of *A. caronei* n. sp., but

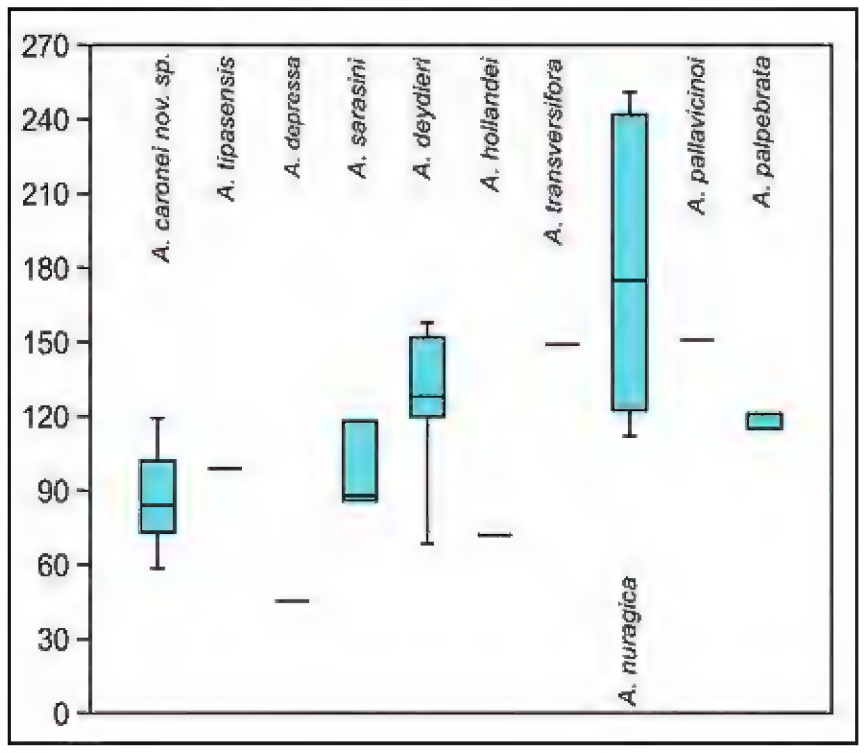


Figure 20. WI comparison between *Amphiope caronei* n. sp. and all other species included in the informal *A. nuragica* group.

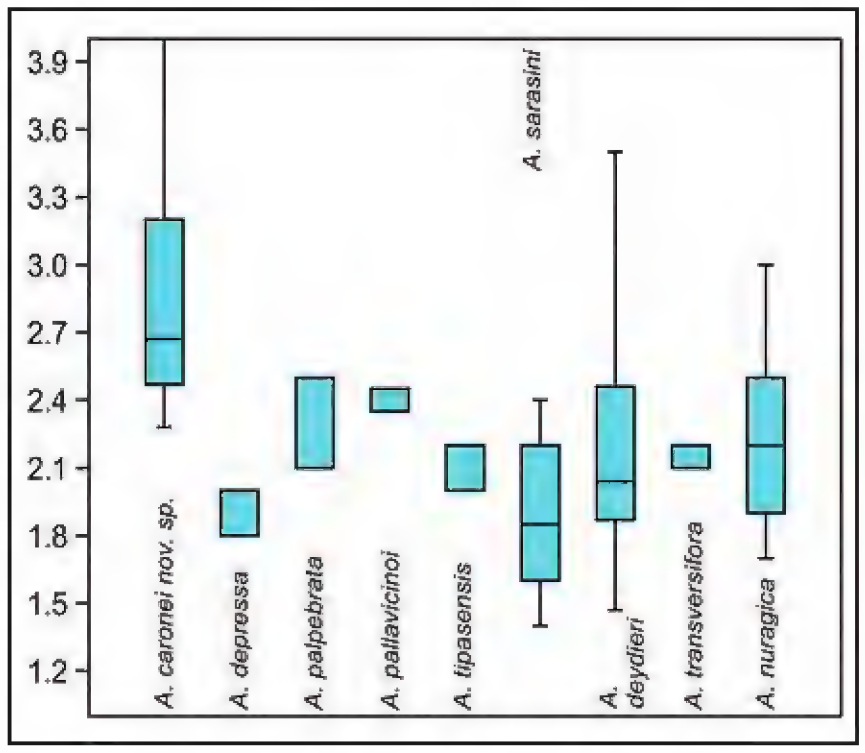


Figure 21. SI comparison between *Amphiope caronei* n. sp. and the other species included in the informal *A. nuragica* group (except *A. hollandei*).

	TL	H%	TW%	PL%	L1%	L2%	SI	WI	L4%	L11%	L12%	pos Pc
VV6 CFA1	66	8.9	121	46	5.6	19	3.4	106	54	11	50	2a-3b
CFACa6	90	11,6	105,5	42	-	-	-	-	-	-	-	
CFACa7	87	10.3	104.5	44	5.9	14.6	2.5	86	54	6.6	47	2a-3b-3a
CFb1	80	8	95,5	40,5	6	15	2,5	90	49	7	45	2a-3b
CFb2 (VVCFb4)	87	-	103	43	6	14	2,4	84	-	11	-	2a-3b-3a
VV3 CFB	80	12,5	103	45	4	16	4	64	51	6,8	-	2a-3b
VV4 CFB2	79		98	44	6	17	2.8	102	55.5		49	—
VV5 CFb3	67	11.9	115	43	5.6	15	2.7	84	54	9.5	48	2a-3b
CFB Ca1	80	10	105	44	5.6	13.5	2.8	76	53	8,6	50	-
CFBCa2	77	10.4	110	43	4.4	13,3	3	58,5	53	8,6	45	2a-3b
CFBCa3	81	9.9	104	45	6.4	16.3	2.5	104	-	8,5	47	-
CFBCa4	75	10.6	108	44	6.4	14.6	2.3	93	50	8.6	50	-
CFBCa5	78	10.9	108	45	5.3	13.8	2.6	73	-	10	49	-
PL1672 Pa	90	11.1	109	44	3.9	15	3.8	58.5	48	11.6	50	2b-2a-3b
VV7 Pa	89	11.2	115	43.5	3.6	17	4.7	61	55.5	8.5	51	2b-2a
VV16 Pa	94	11.2	105	-	4.6	13	2.8	60	-	10	-	2b-2a-3b
PL1728 Pa	76	14.5	112	42.5	5.6	14.5	2.6	81	56	10,8	48	2b-2a-3b
VV19CaUP1	74	11.5	109	44	7.1	16.8	2.4	119	54.5	6.7	49	-
VV18CaUP2	93	11,8	111	44	5.3	15,2	2.9	81	57	11,2	49	2a-3b
VV8 Zu	80	12.5	114	44	5	16.5	3.2	82.5	52	7.3	48	—
VV17CaCGMa2	81	8,6	106	44.5	5	16,3	3,3	91,5		9,8	48	-
CG1	82	11	112	42	4	14,9	3.7	99		9,6	48	2b-2a-3b
CG2	85	12,5	106	46	5,2	12,4	2,4	64,5	52	7	46	2b-2a-3b
CG3	89	11,6	96	46	4,6	11,3	2,4	52	55	8		2b-2a-3b
CG4	87	11,8	108	45,5	6,4	16,7	2,6	106	57	11,2		2b-2a-3b
range	66-94	8-14.5	95.5-121	40.5-46	2-7.1	11.2-19	2.3-4.7	52-119	48-57	6.6-11.6	45-50	
mean		11	107	44	4.9	15	2.9	80	53	9	48	

Table 1. Biometric measures taken in the studied sample.

it differs by the number of plates in the interambulacrum 5 that is: 3 against 2 in column "a", 4 against 2-3 in column "b". *Amphiope sarasini* has a larger PL and a higher test (TH=14% against 11% TL). Finally, the group of species formed by *A. tipasensis*, *A. sarasini* and *A.* sp. 1 from Valencia (Stara et al., 2015), shares a high number of plates in the oral intrambulacrum 5, with the periproct far from the posterior margin. In fact, *A. sarasini* has L11=12–13% TL; *Amphiope* sp. 1 from Valencia has L11 up to 20% TL; *A. tipasensis*, has L11=12.5% TL, against an average of 9% TL in *A. caronei* n. sp.

Pomel (1885-87), in the original description of *A. depressa*, cited five genital pores, instead of four, which seem characteristic of this genus, but observed in only one specimen.

Since it was not possible to trace the types of Pomel collection (originally, it was not indicated their institutional repository, or the type locality, Cotteau et al., 1889, were also not able to locate them), it is not possible to verify this morphological particular.

CONCLUSIONS

The aim of this work was to define the systematic position and the geographic diffusion of the Cessaniti *Amphiope* populations. This knowledge could result to be very useful to improve the paleogeographic reconstruction of peri-Mediterranean regions during the Oligo-Miocene. So far, no known species of *Amphiope* seem to have a wide diffusion, and also *A. caronei* n. sp. seems to have only a loco-regional diffusion. However, research in progress could highlight new sites and the taxonomy based on modern approach could help to improve the true relationships between the large number of forms previously called *Amphiope* "*bioculata*" by Philippe (1998).

Studies on *Amphiope* taxonomy in regions such as Morocco, Algeria, Libya, Egypt, Turkey were scanty and need to be updated. Only when the old finds are redefined by modern approach, we'll be able to known the real diffusion areas of the various species belonging to this genus.

Finally, the wide variation in the petalodium size in both fossil and Recent astriclypeids, in particular in the genera closely related to *Amphiope*, such as *Sculpsitechinus*, *Paraamphiope* and *Echinodiscus* (for an overview see Stara & Sanciu, 2014 and Fatemi et al., 2016), opens up an investigation on the correlation between the size of this respiratory organ, typical of the scutelliforms, and the ecological conditions influencing the percentage of dissolved oxygen in seawater.

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Purpuricenus (s. str.) *coccineus* Breit, 1917: a distinct species endemic from Calabria, Italy (Coleoptera Cerambycidae Cerambycinae Purpuricenini)

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ABSTRACT *Purpuricenus* (*s. str.*) *coccineus* Breit, 1917 (Coleoptera Cerambycidae Cerambycinae Purpuricenini) is revaluated as a distinct species from Calabria (South Italy). For a long time it was thought to be a synonym of *Purpuricenus* (*s. str.*) *globulicollis* Dejean, 1839.

KEY WORDS Cerambycidae; Purpuricenini; *Purpuricenus*; Italy.

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INTRODUCTION

During the summer of 2017, one of the authors (Luciano Arcorace) had the opportunity to visit a couple of times the Calabria region (the most southern continental Italian region) and, thanks to the use of sweet traps, collected a small series of *Purpuricenus* Germar, 1824, that appears immediately very peculiar because of the totally red coloured elytra without any black spot. After a deeper investigation, we found out that it belongs to a distinct species, *Purpuricenus* (*s.str.*) *coccineus* Breit, 1917, strictly related with *Purpuricenus* (*s.str.*) *globulicollis* Dejean, 1839, but well characterized by several differences that are illustrated in this paper.

RESULTS

Systematics

Ordo COLEOPTERA Linnaeus, 1758
Superfamilia CHRYSOMELOIDEA Latreille, 1802
Familia CERAMBYCIDAE Latreille, 1802
Subfamilia CERAMBYCINAE Latreille, 1802
Tribus PURPURICENINI Thomson, 1861
Genus *Purpuricenus* Dejean, 1821
Subgenus *Purpuricenus* Dejean, 1821

Purpuricenus* (*s. str.*) *coccineus Breit, 1917
bona species (Figs. 1–5)

Purpuricenus globulicollis Mulsant var. nov. *coccineus* - Breit, 1917: 73

TYPE LOCALITY. S. Eufemia d'Aspromonte (Calabria, Italy) Breit (1917).

ORIGINAL DESCRIPTION. Breit (1917): "*Mir liegt ein von Paganetti-Hummler in Süd-Italien (Calabrien) bei Sta. Eufemia d'Aspromonte gesammeltes Stück dieser Art vor, das vollkommen einfarbig ziegelrote Flügeldecken hat. Anch die Oberseite des Halsschildes ist rot, bis auf den schmalen Vorder- und Hinterrand und zwei kleine mit der Spitze zueinander gerichtete längliche Fleckchen an der Basis*

vor dem Schildchen, welche ebenso wie dieses, schwarz sind. An den Flügeldeckenspitzen ist nur das äußere Zähnchen vorhanden, während das Zähnchen an der Naht fehlt".

TYPE MATERIAL. We found the type specimen of *P. coccineus* (Fig. 4) preserved in the Naturhistorisches Museum of Basel (Switzerland). It is a male, long 15.2 mm and wide 4.6 mm, in good conditions, missing the right antenna from the second segment and perfectly fitting with the original description. Under the type specimen there are 7 labels (Fig. 5): "*Calabria / Sta.Eufemia / d'Aspromonte*" printed, white; "*Paganetti*" printed, white - "globulicollis / *Dej.* / *ab.* coccineus / *Breit*" handwritten by Breit - "globulicollis / *Muls. a.* / coccineus / *Brt.*" handwritten by Breit - "*Type*" red, printed - "*ex Orig. Samlg. / J. Breit Wien*" red, printed - Purp. Globulicollis / *ab.* Coccineus / *det. G. Sama 19"* handwritten and printed by G. Sama (Cesena, Italy).

EXAMINED MATERIAL. *Purpuricenus coccineus* Breit, 1917. Italy. Calabria (Reggio Calabria), Caulonia, Villaggio Ziia, Località Strada Ferrata, 1040 meters, 1.VI–22.VII.2017, wine traps, L. Arcorace legit; idem, Caulonia, Villaggio Ziia, Località Martucci, Cimitero dei Tedeschi, 980 meters, 1.VI–22.VII.2017, wine traps, L. Arcorace legit.

Purpuricenus (*s. str.*) *globulicollis globulicollis* Dejean, 1839. France. 1 male: Dept. 34, La Virenque, VII.1990; 2 males, 2 females: Dept. 26, Aucelon, VII.1984; 2 females: Dept. 69, S.te Foy, 22.VII.1990; 2 males: Herault, Ceilhes, VII.1999; 1 male: Alpes Haute Provence, L'Escale, 900 m., 25.VII.1984, Reyner legit; 1 male: Drôme, Avalon, 600 meters, VIII.1980, D. Keith legit.

Italy. 5 males, 5 females: Friuli Venezia Giulia, Udine province, Alpi Giulie, Chiusaforte, 27.VI–15.VIII.2011, P. Rapuzzi legit; 12 males, 4 females: Friuli Venezia Giulia, Udine province, Alpi Giulie, Chiusaforte, Val Dogna, Chiutzuquin vill., 27.VI–15.VIII.2011, P. Rapuzzi legit; 27 males, 22 females: Friuli Venezia Giulia, Triest province, Duino, Medeazza, 3.VI–6.VII.2007, P. Rapuzzi legit; 3 males, 2 females: Friuli Venezia Giulia, Triest province, Duino, VII.2000, F. Ledouc legit; 9 males, 9 females: Friuli Venezia Giulia, Triest province, Triest, loc. Gropada, 10–23.VII.1996, P. Rapuzzi legit; 24 males, 14 females: Friuli Venezia Giulia, Gorizia province, Monfalcone, loc. Sablice, 3.VI–6.VII.2007, P. Rapuzzi legit; 9 males, 12 females: Friuli Venezia Giulia, Gorizia province, Savogna d'Isonzo, Monte San Michele, 7.VI–26.VII.2007, P. Rapuzzi legit; 10 males, 5 females: Friuli Venezia Giulia, Gorizia province, Doberdò del Lago, Jamiano, 3.VI–6.VII.2007, P. Rapuzzi legit; 1 male, 2 females: Veneto, Verona province, Lessinia, Peri-Malga Campo, 20.VI–6.VII.2012, A. Sette legit; 3 males, 3 females: Veneto, Verona province, Monte Baldo, Rivoli Veronese, 4–25.VII.2014, A. Sette legit; 1 male: Lazio, Roma province, Segni, Monte Lupone 16.VII–24.VIII.2016, M. Gigli legit; 1 female: Abruzzo, Chieti province, Majella, 3.VII.2003, B. Biscaccianti legit; 1 female: Basilicata, Matera province, Miglionico, 6.VII.1991, G. Proscia legit; 3 males, 6 females: Sicily, Palermo province, Madonie Mts., Piano Zucchi, 13.VI–8.VII.2006, P. Rapuzzi & G. Sama legit; 1 female: Sicily, Palermo province, Isnello, loc. Torre Montaspro, 27.VI.2003; 1 female: Sicily, Messina province, Nebrodi Mts., Monte Soro, 16.VI–7.VII.2006, P. Rapuzzi & G. Sama legit.

Slovenia. 76 males, 78 males: Nova Gorica, Monte Nanos, 18–28.VII.2005, P. Rapuzzi legit; 1 male: Nova Gorica, Ajdovscina, Sturje, 17.VII–3.VIII.2005, P. Rapuzzi legit; 4 males, 8 females: Nova Gorica, Solkan, Sveta Gora, 6.VII–26.VII.2007, P. Rapuzzi legit; 1 female: Nova Gorica, Korada Gora, Dobrovo v Brdih, 3.VI–6.VII.2008, P. Rapuzzi legit; 3 males, 4 females: Istria, Koper, Korte, 1.VI–18.VII.2009, P. Rapuzzi legit; 1 male: Istria, Koper, Presnica, ex larva *Ulmus* sp., 25.VI.2011, P. Rapuzzi legit; 1 male: Ajdussina, Monte Nanos, 03.VIII.2013, M. Benelli legit.

Croatia. 1 male: Krajna, Karlovac, Slunj, Suhodol Budacki env., 6.VI–13.VII.2013, P. Rapuzzi legit; 1 female: Lika, Gospić, Ljubovo, 3.VI–1.VII.2008, P. Rapuzzi legit; 1 male: Kvarnar, Rijeka, Is. Krk, Baška, 15.VII.1973, Paolo Rapuzzi legit; 1 female: Kvarnar, Rijeka, Is. Krk, Punat, 5–24.VI.2003, P. Rapuzzi legit; 1 male: Kvarnar, Rijeka, Selce, 28.VI.1994, T. Kovacs legit; 3 males, 1 female: Kvarnar, Rijeka, Jadranovo, 28.VI–12VII.2011, M. Carraretto legit; 1 male, 1 female: Velebit, Karlobag, Susanj, VI.2001, P. Rapuzzi legit; 1 female: Velebit, Karlobag, Vidovac, VI.2001, P. Rapuzzi legit; 1 male, 1 female: Istria, Rijeka, Matulj, 3 Km W-Permani, 6.VI–13.VII.2013, P. Rapuzzi legit; 1 male: Velebit, Gospić, Brusane, 27.VI–15.VII.2011, M. Malmusi-R. Poloni legit; 1 female: Velebit GS, Vidovac-Susanj 1.VII–15.VII.2011, M. Malmusi legit.

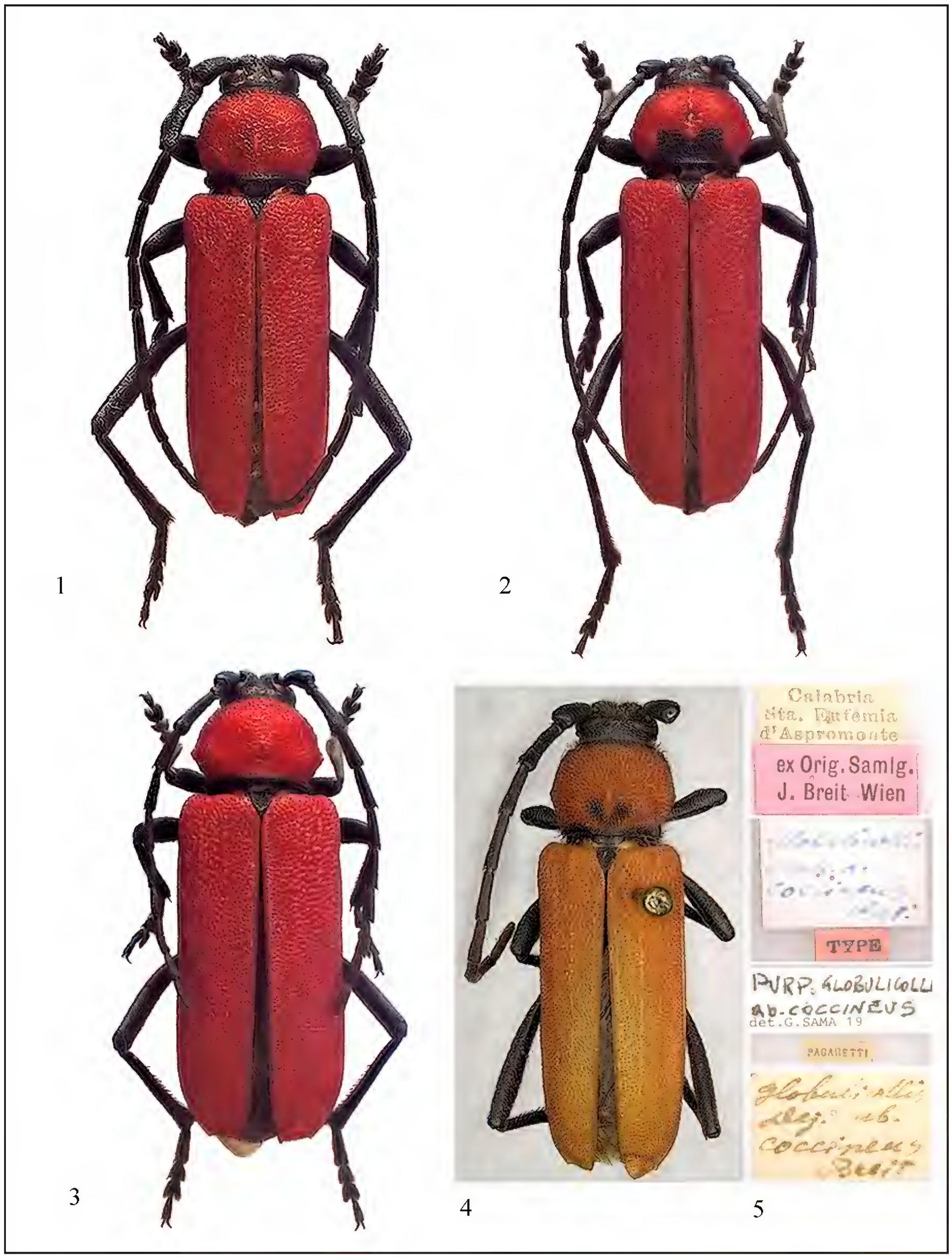

Figure 1. *Purpuricenus coccineus* male, habitus. Italy, Calabria (RC), Caulonia, Villaggio Ziia, Località Martucci, Cimitero dei Tedeschi, 980 meters, 1.VI-22.VII.2017. Figure 2. *Purpuricenus coccineus* male, habitus. Italy, Calabria (RC), Caulonia, Villaggio Ziia, Località Strada Ferrata, 1040 meters, 1.VI–22.VII.2017. Figure 3. *Purpuricenus coccineus* female, habitus. Italy, same data of figure 1. Figure 4. *Purpuricenus coccineus* holotypus. Figure 5. *Purpuricenus coccineus* holotypus labels.

Greece. 1 male: Thessaly, Ossa Mt., Kokkino Nero, 24.VI–10.VII.2002, L. Kruszelnicki legit; 8 males, 9 females: Eubea, Pili, 16.VI–25.IX.2014, A. Sette legit; 1 male, 2 females: Eubea, Prokopi, 25.VI–11.IX.2010, A. Sette legit; 1 male: Eubea, Aghios, 30.VI.1989, A. Sette legit; 22 males, 10 females: Eubea, between Kerinthos and Strofilia, 25.VI–09.IX.2013, A. Sette legit; 1 male: Peloponnese, Lakonia, Karies env., 4–5.VI.2008, I. Martinů legit.

Russia. 1 male: SE-Siberia, Cheljabins reg., Snezinsk env., 22.VII.2013, S. Rybalkin legit; 1 male: Siberia, Altai reg., Ulgan distr., Chulyshman riv. valley, 12 Km SSE Ko, 550 meters, 6–8.VII.2013 (sub. *Purpuricenus tscherepanovae* Tscherepanov, 1980).

Purpuricenus (*s. str.*) *globulicollis skypetarum* Rapuzzi et Sama, 2013. Albania. Holotypus male: Durres, Bizë, 15–24.VI.2007, sugar traps, P. Rapuzzi & G. Sama legit (coll. P. Rapuzzi); Paratypes: 66 males, 54 females: Same data (coll. P. Rapuzzi, coll. G. Sama); 8 males, 4 females: Shkodër, M.te Ghzoprës (West slopes), 400 meters, 15–24.VI.2007, sugar traps, P. Rapuzzi & G.Sama legit (coll. P. Rapuzzi); 4 males, 6 females: Tiranë, Mal. I Dajtit, 16–24.VII.2007, sugar traps, P. Rapuzzi & G. Sama legit (coll. P. Rapuzzi) (Type series).

Greece. 2 males, 2 females: Etolia, between Palagros and Mitikas, 15.VI–3.VII.2010, sugar traps, A. Sette legit (coll. P. Rapuzzi) (Type series); 1 male, 1 female: Epiro, Milia, 1–15.VIII.2013, G. Giannini & G. Rondinini legit.

DISTRIBUTION AND BIOLOGY. The new localities of *P. coccineus* are situated on the Ionic coast, relatively close one to the other, and far from the type locality (San'Eufemia di Aspromonte) that is located on the Tirrenic coast of Calabria, Italy. It is very likely that, after deeper researches, other locality and populations for this very interesting species could be found in Calabria. From the closest region (Sicily and Basilicata) we have seen only *P. globulicollis*. For this reason, we believe that it should be regarded as a Calabrian endemism.

The two new localities where the specimens have been collected are located on a north-facing slope: the habitat is an intersection zone between the temperate deciduous forest and the mediterranean evergreen oak forest. The main trees species of this habitat are holm oak, *Quercus ilex* L., European beech, *Fagus sylvatica* L., Italian maple, *Acer opalus* subsp. *obtusatum* (Waldst. et Kit. ex Willd.) Gams).

COMPARATIVE NOTES. We studied the type and 6 specimens (5 males and 1 female); they are perfectly fit with the type.

Figure 6. *Purpuricenus coccineus* aedeagus. Italy, Calabria (RC), Caulonia, Villaggio Ziia, Localitȁ Strada Ferrata, 1040 meters, 1.VI-22.VII.2017. Figure 7. *Purpuricenus coccineus* paramers, same data of figure 6. Figure 8. *Purpuricenus globulicollis* aedeagus. France, Herault, Ceilhes, VII.1999. Figure 9. *Purpuricenus globulicollis* paramers, same data of figure 8.

All specimens are without any black spot on the elytra and the pronotum is totally red or with small black spots situated near the base. *Purpuricenus coccineus* is strictly related to *P. globulicollis*, but it is easy to separate, except for the very peculiar color, for the totally absence of short and sparse black erect hairs on the elytra. These hairs are present in *P. globulicollis* and they are denser on the lateral side and upon the black spot on the middle of the elytra. In the Calabrian species, the elytra are less convex and deeper punctured than in *P. globulicollis*, the points are denser and strong toward the elytral apex as well. In both the sexes the elytra are evidently shorter and larger. Pronotum is more globular in both the sexes in the Calabrian species and it shows flatter callosities on the disk. These callosities are more prominent in *P. globulicollis*. Legs and antenna are relatively shorter and a little stouter. The paramers look very different between these two species. In fact, in *P. coccineus* they are stout and fused almost up to the apex and in *P. globulicollis* they are longer and dived for the two thirds of their length (Figs. 7, 9). Aedeagus is different as well. In the Calabrian species it is shorter, enlarged at the sides in the middle and with the apex larger and shortly acuminate. In *P. globulicollis*, aedeagus is evidently longer, with parallel sides and the apex acuminate (Figs. 6, 8).

The 6 specimens studied in this paper plus the type specimen show a range of size between 16 to 11 mm. for the males. The only female is long 14 mm. They are very similar in any other characteristics, except the red color on pronotum, that changes a little. Three specimens (2 males and 1 female) show the pronotum totally red, the other 3 specimens from the new locality plus the type show a more or less small black spot located in the middle of the base. Shape and dimensions of this pronotum spot vary from two small aligned dots linked at the base to a triangular spot extending over the middle of the pronotum (1 specimen).

In examined specimens of *P. coccineus,* the prosternum is totally black and the red coloration of pronotum never reach the lateral lower edge of pronotum (prosternum in *P. globulicollis* is often totally or partly red, and the red colouration of pronotum usually reach the lateral lower edge of pronotum). The elytral apex present two more or less evident teeth. Breit (1917) in the original description mentioned only one tooth at the external side of the elytral apex (*...An den Flügeldeckenspitzen ist nur das äussere Zähnchen vorhanden, während das Zähnchen an der Naht fehlt*) but it is clear that the type has problems of elytral development at the apex.

Based on the the peculiar color it can resemble *P. schurmanni* Sláma, 1985 (endemic from Crete). Nonetheless, it is very easy to separate based on the glabrous elytra (elytra with short light erect hairs in the Cretan species). Moreover, *P. schurmanni* shows often reddish legs and antennae, that are instead totally black in *P. coccineus*. The shape of pronotum is different as well, more transverse and globose in *P. schurmanni*.

Remarks. Inside the Catalogue of Paleartic Cerambycidae (Löbl & Smetana, 2010), *P. coccineus* is missing due to a mistake. In fact, according to the ICZN (art. 45.6.4: *It is subspecific if first published before 1961 and its author expressly used one of the terms "variety" or "form" (including use of the terms "var.", "forma", "v." and "f."), unless its author also expressly gave it infrasubspecific rank, or the content of the work unambiguously reveals that the name was proposed for an infrasubspecific entity, in which case it is infrasubspecific."*) since it was described as "*var.*" before 1961, the name should be regarded as available and for this reason it must be accepted as valid.

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Contribution to the knowledge of the spider fauna (Arachnida Araneae) of the Maltese Archipelago

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ABSTRACT In this paper, new spiders (Arachnida Araneae) from the Maltese Archipelago are reported. Particularly, 3 genera and 5 new species found during a recent trip to Malta and Gozo islands are reported here. The presence in these islands of another species is confirmed. Additional biological and taxonomic notes are provided.

KEY WORDS Araneae; new data; first records; Malta.

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INTRODUCTION

According to recent work, the species of spiders (Arachnida Araneae) present in the Maltese Archipelago are 141. Of these, 4 species are classified only for the genus, and other 4 species only for comparison with other species. Overall, they are divided into 108 genera and 33 families (Pfliegler et al., 2017).

In this paper 3 genera and 5 species for the Maltese Archipelago are cited for the first time; the presence in these islands of another species is confirmed; the first images of the species that is probably *Ozyptila leprieuri* Simon, 1875, found during a recent trip to this island, are provided.

MATERIAL AND METHODS

All the samples were collected on sight, some under the rocks, others on their webs, and the majority during the evening and night hours. The samples have been treated with ethyl acetate in the laboratory, observed with binoculars, and photographed with a Nikon D90 and a 100 mm macro lens. They were then stored in centrifuge containers, of different sizes, in 75% ethanol.

All samples were collected by the author and are kept in his collection.

The classification, taxonomic order and nomenclatural arragement, follow World Spider Catalog (2018).

For each species, literature, chorotype, and biological notes are provided (see also Roberts, 1995; Nentwig et al., 2018).

RESULTS

Systematics

Ordo ARANEAE Clerck, 1757
Familia AGELENIDAE C.L.Koch, 1837
Genus *Tegenaria* Latreille, 1804

Tegenaria pagana C.L. Koch, 1840

EXAMINED MATERIAL. GOZO, Nadur, 36°03'22.7"N 14°18'20.1"E, 18.XI.2017, 1 male and 1 female subadult.

DISTRIBUTION. Europe to Central Asia. Introduced to USA, Mexico, Brazil, Chile.

REMARKS. New species for the Maltese Archipelago. The specimen was sampled on its canvas, inside a small cave. Despite the presence of several canvases, in one of which I found the moult of a female specimen, I have not found other specimens. The male was collected while walking on the walls, perhaps looking for a female.

Familia ARANEIDAE Clerck, 1757
Genus *Siwa* Grasshoff, 1970

Siwa dufouri (Simon, 1874)

EXAMINED MATERIAL. Malta, Mellieħa, 35°57'29.3"N 14°21'55.0"E, 17.XI.2017, 1 female.

DISTRIBUTION. Western Mediterranean.

REMARKS. New genus and new species for the Maltese Archipelago. The determination of this species was made following the description of Levy (1986), despite the absence of the male and the impossibility of comparing the specimen with another of the same species, the author determines it as written.

Familia DICTYNIDAE O. P.-Cambridge, 1871
Genus *Nigma* Lehtinen, 1967

Nigma walckenaeri (Roewer, 1951)

EXAMINED MATERIAL. Malta, Lord Strickland, Ħ'Attard, 35°53'44.7"N 14°26'47.0"E, 17.XI.2017, 1 male and 1 female.

DISTRIBUTION. Europe, Turkey, Caucasus.

REMARKS. New genus and new species for the Maltese Archipelago. In Sicilian samples I could see the opportunism in conserving one's own silk. Day 14.I.2017 I observed two specimens of *N. walckenaeri*, a male and a female, living in two separate cells of a beehive *Polistes* sp., probably abandoned. I took the hive with its tenants in the laboratory, and I put a container inside. Day 20.I.2017 the female has spawned in a simple cocoon, outside the hive, in one of the container walls. Day 22.II.2017 the eggs hatched, and I counted 38 spiderlings. All samples were released the next day in the same place of capture.

Familia THERIDIIDAE Sundevall, 1833
Genus *Episinus* Walckenaer, 1809

Episinus cfr. ***algiricus*** Lucas, 1846

EXAMINED MATERIAL. Malta, Cirkewwa, Mellieħa, 35°59'06.1"N 14°20'04.2"E, 18.XI.2017, 1 male subadult; Nadur, Malta, 36°03'19.8"N 14°18'10.9"E, 18.XI.2017, 1 male subadult.

DISTRIBUTION. Portugal, Spain, France, Italy, Northwest Africa.

REMARKS. New genus and new species for the Maltese Archipelago. *Episinus algiricus* is very similar to the *E. angulatus* Blackwall, 1836. However, in addition to the observation of the reproductive organs, that is not possible in the samples because still immature, *E. angulatus* differs for the color of the legs, which are dark brown. On the contrary, those of the *E. algiricus*, as well as its color overall, are tending to yellow/sand.

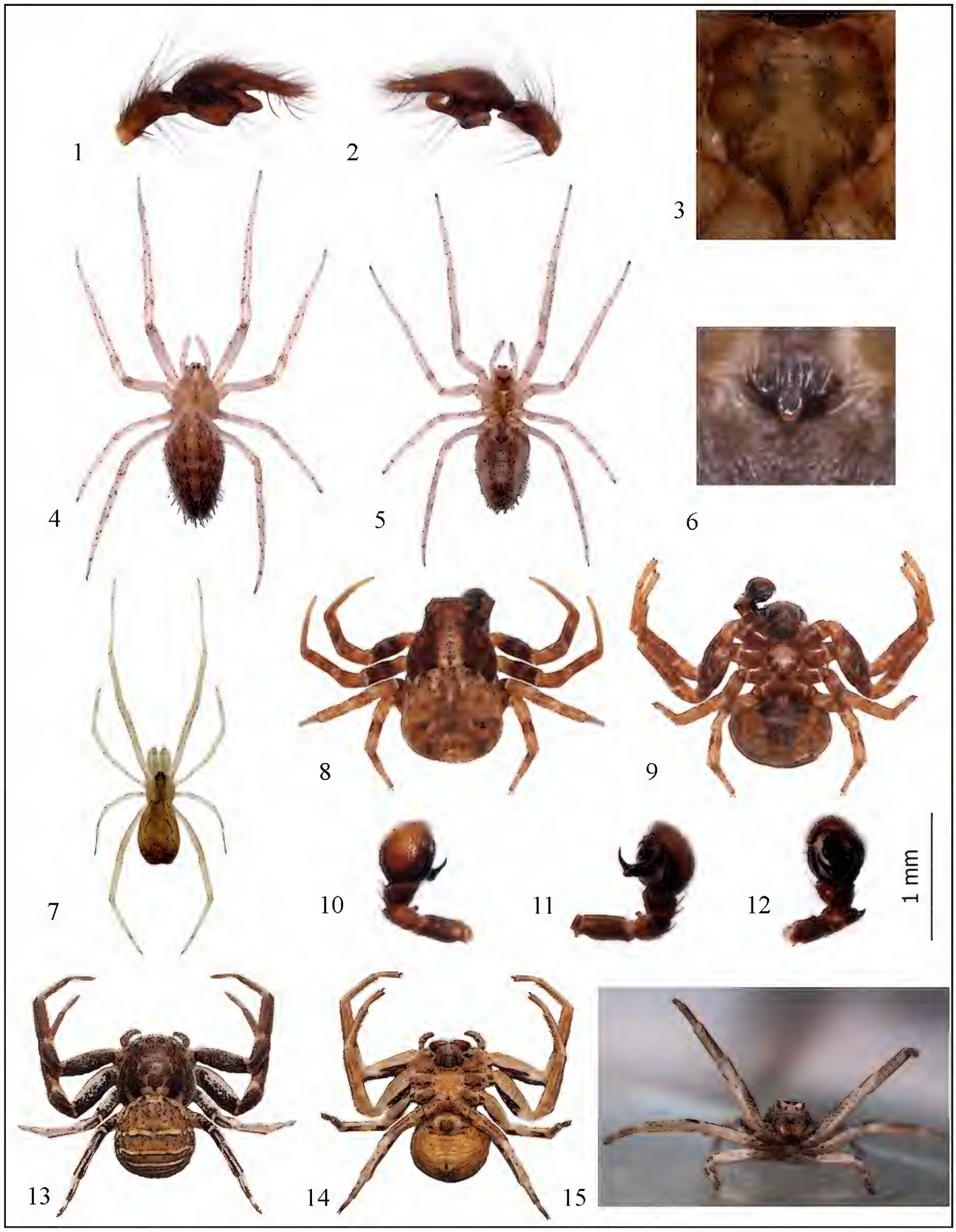
Familia THOMISIDAE Sundevall, 1833
Genus *Ozyptila* Simon, 1864

Ozyptila cfr. ***leprieuri*** Simon, 1875

EXAMINED MATERIAL. Malta, Cirkewwa, Mellieħa, 35°59'06.1"N 14°20'04.2"E, 18.XI.2017, 1 male.

DISTRIBUTION. Marocco, Algeria.

REMARKS. New species for the Maltese Archipelago. The sample was collected under a stone, in a garigue environment. Its cryptic colors can be confused with the color of the earth and when it felt it was in danger, clutching its paws towards the breastbone, it remained still. In literature, there is not an image of the species. The specimens have been attributed to *O. leprieuri* following Simon's description (1875). This species is similar to *O. claveata* (Walckenaer, 1837), but although very similar, some characteristics related to male genital parts, leads us to think that it is attributable, with reservation, to *O. leprieuri*. I will report below the translation of Simon (1875) regarding the apophysis



Figures 1–3. *Tegenaria pagana*: palp (length 1.4 mm) (Figs. 1, 2) and sternum (length 1.8 mm) (Fig. 3). Figures 4–6. *Siwa dufouri* female (length 7 mm): dorsal view (Fig. 4), ventral view (Fig. 5), epigyne (width 0.4 mm) (Fig. 6). Figure 7. *Episinus* cfr. *algiricus* male subadult (length 3.8 mm). Figures 8–12. *Ozyptila* cfr. *leprieuri* male (length 3 mm): dorsal view (Fig. 8), ventral view (Fig. 9), palpus: internal side view (Fig. 10), side view (Fig. 11), frontal view (Fig. 12). Figures 13–15. *Xysticus bufo* female (length 6.2 mm): dorsal view (Fig. 13), ventral view (Fig. 14), defensive behaviors (Fig. 15).

of the male bulb of both species. For *O. claveata* this is the description: "*the black bulb, presents, towards the inner center, a very strong apophysis, thick at the base, acute at the extremity, directly obliquely to the back, almost to the lower tibial apopliysis*". For *O. leprieuri* this is description: "*bulb with a rather large vertical medial apophysis, divided into two equal branches, acute and divergent at the extremity*".

Following Simon's description (1875), in which the specimen reflects dimensions and approaches the anatomical description, it is attributed to the species mentioned above with reserve that these are the first images of the species and this is the first European reporting of this species.

Genus *Xysticus* C.L. Koch, 1835

Xysticus bufo (Dufour, 1820)

EXAMINED MATERIAL. Cirkewwa, Mellieħa, Malta, 35°59'06.1"N 14°20'04.2"E, 18.XI.2017, 1 female.

DISTRIBUTION. Mediterranean.

REMARKS. *Xysticus bufo* was already reported for the Maltese islands, through a male sample of the species and only for comparison, by Baldacchino et al. (1993) and Pfliegler et al. (2017). This is the confirmation that the species has been present on the Maltese Archipelago.

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I particularly thank Paolo Pantini (Bergamo, Italy) for his constant help in determining the samples, Ignazio Sparacio (Palermo, Italy), and Marco Capritti (Palermo, Italy) for their friendship, and my girlfriend and my family for their support.

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Biodiversity Journal, 2018, 9 (1): 99–103

On the coloration of the wild rabbit, *Oryctolagus cuniculus* (Linnaeus, 1758) (Mammalia Leporidae), in the Maltese Archipelago

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ABSTRACT Although most non-scientific literature listing wild rabbit, *Oryctolagus cuniculus* (Linnaeus, 1758) (Mammalia Leporidae), in the Maltese islands mentions the occurrence of two colour morphs in the Maltese islands, an attempt at describing in scientific detail such coloration has never been made. Wild rabbits in the Maltese islands occur in two dominant morphs; the grey agouti and the yellow morph. In this article, a detailed description of each variation was given with regards to 'dorsum', 'flanks', 'nape', and 'ventrum', as well as the specific descriptions of 'head', 'tail', and 'ear tip'. Hair colour bands for both morphs are also given. Predation and camouflage are explored as the major driving force behind the high level of occurrence of the wild rabbit *Oryctolagus cuniculus* sporting the yellow morph. This when compared to other countries.

KEY WORDS *Oryctolagus cuniculus*; Malta; colouration; lagomorph; morphology.

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INTRODUCTION

The European wild rabbit *Oryctolagus cuniculus* (Linnaeus, 1758) (Mammalia Leporidae) is described as an animal with a coat of greyish-brown agouti coloration.

Toschi (1965) gives a detailed description of the coloration and coat of the European wild rabbit and he states that the typical greyish-brown coloration is due to a series of bands of colour found on every single hair. He identifies 5 such colour bands on hairs taken from the dorsal part of the coat. The colours described are as follows, starting from the base; light grey, reddish-brown, greyish-black, creamy-yellow and black.

A similar description is given by Schilling & Singer (1986) and Sarà (1998).

Haltenorth & Diller (1988) describe *O. cuniculus* as having "*thick and woolly pelage*". They describe the colour as greyish-brown on the upperside with the flanks being lighter, a rusty-red nape patch, underside (throat to tail) pale grey to white, ear upper edge and upper side of tail, black.

Furthermore, they present (Haltenorth & Diller, 1988) a list of noted variations. Colour variations listed are; white, yellowish, foxy red, bluish-grey, black. Sarà (1998) notes that some of the southern populations from the Mediterranean area tend to have a lighter coat.

Coat coloration in lagomorphs was very specifically also discussed and analysed by Stoner et al. (2003). In their study regarding the adaptive significance of coloration in lagomorphs, they analysed pelage coloration in relation to habitat type,

geographical region, altitude, and behaviour. Apart from the overall coloration, they investigated the significance of tail and ear tip coloration.

Stoner et al. (2003) presented a very detailed table listing variables for the Leporidae and Ochotonidae species. Each species was described with regards to particular variables. The physiological traits described were; dark/light overall coloration, red/grey overall coloration, and white in winter, white ventral coloration, dark/white ear tips, dark/white tail. They also included ecological traits (habitats: woodland, grassland/scrubland, rocky, swamp, desert, tundra) and habitual traits (diurnal, crepuscular, nocturnal, burrow use, and social). Information about the coloration and behavioural ecology of each species was collected from an extensive range of literature.

After condensing the data collected, Stoner et al. (2003) described *O. cuniculus* as having grey overall coloration, a white ventrum, dark ear tips, and a dark and white tail. As for the habitat, they described it as an inhabitant of grassland, scrubland and rocky environments. Also, it was found to occur in arctic, subarctic, subtropic and tropic climates. Behaviour-wise, the European rabbit was found to have crepuscular and nocturnal tendencies, to live in burrows and to be a social animal.

A mention of a variation in colour in Maltese *O. cuniculus* was presented by Adams (1870), that listed the rabbit as one of the few indigenous quadrupeds living on these Islands. He states (Adams, 1870) that "[*the rabbit*] i*s seemingly a variety with a sparser fur, and lighter brown shades on the upper parts than the rabbit of Northern Europe*". However this description is very broad and leaves a lot of room for discussion.

It is unclear when the *O. cuniculus* first occurred in Malta. Remains identified as appertaining to *O. cuniculus* were excavated in only one site on the island of Malta, at Ghar Dalam (Despott, 1923). These remains were found in superficial sediments associated with bones of domestic animals such as sheep, pigs, and goats (Pleistocene period) (Boessneck & Kuver, 1970). Remains found could not be identified as coming from wild or domesticated, however this indicates that rabbits have inhabited Malta, at least, since Malta was inhabited by the first people (circa 5000 BC).

The hypothesis presented in most literature is that *O. cuniculus* is not native to the Maltese islands and it was brought here by man in ancient times, with the present wild rabbit being the descendant of the domesticated rabbits which have been released or which managed to escape (Baldacchino et al., 1990.)

Although the wild rabbit is the largest land mammal in the Maltese islands, practically no studies on the Maltese *O. cuniculus* have been conducted, except for a study which was aimed at establishing the average craniometric data for the islands of Malta and Comino (Falzon, personal data).

Reference to the Maltese wild rabbit has been made in many local publications (French Angas, 1842; Baldacchino & Schembri, 2002). Morphological data present in such literature was always adopted from European references (Miller, 1912; Van Den Brink, 1967; Harrison Matthews, 1968; Savona Ventura, 1982; Biju-Duval et al., 1991; Macdonald, & Barrett, 1993; Sarà, 1998; Branco et al., 2000; Smith & Boyer, 2008).

One feature which stands out prominently when studying the Maltese *O. cuniculus* population is that although the local population of rabbits consists of the grey agouti morph commonly described in literature, in Malta one can observe quite frequently the occurrence of yellowish rabbits, or "*fenek ahmar/isfar*" as called by the locals.

The aim of this study is to give a detailed description of the two common colour varieties of *O. cuniculus* occurring on the Maltese islands.

MATERIAL AND METHODS

Data collection

Data concerning coloration, distribution and occurrence has been directly collected by the author, and also through various cited sources. All the analysed samples were collected under license.

Coloration description

Specimens of *Oryctolagus cuniculus* was described as grey agouti or yellow based on their general appearance. Description of each variation was then given with regards to 'dorsum', 'flanks', 'nape', and 'ventrum'. Specific descriptions of 'head', 'tail', and 'ear tip' was also given. Ear tip

coloration was categorised as either dark or white. Dark includes black tips, dark brown tips, and tips which are darker than the rest of the ears, while white tips includes tips which are not pure white, but evidently lighter than the ears. Tails description was given for the upper part as the lower part was included with the ventrum.

An attempt was also made to describe the colour bands on hairs taken from the dorsal part of the coat for both morphs.

RESULTS

The Tables 1 and 2 describe the overall appearance, in terms of coloration, of the grey agouti and yellow morph respectively. Unfortunately, there is no standardised methodology for defining colouration in mammals.

Grey Agouti Morph (Figure 1) hair colour bands are as follows starting from the base: Light Grey, Fawn, Brown Black, Creamy Yellow, Black Tip.

Yellow Morph (Figure 2) hair colour bands are as follows starting from the base: Pale Fawn, Fawn, Sandy, Sandy Brown, Fawn Tip.

DISCUSSION AND CONCLUSIONS

Records of yellow morph rabbits have been recorded in most places around Malta, as well as on the neighbouring island of Gozo. The colony on Comino consists entirely of yellow morph rabbits.

From field observations, one can deduce that it's possible to find rabbits of both colours originating from the same rabbit colonies.

We have observed both yellow and grey colour morphs living in the same colony of rabbits, and informants have reported finding nests of kits comprised of different colours. In March 2012 (at Wardija) and June 2014 (at Mosta), specimens of both colours where observed feeding together in close proximity and interacting; nuzzling and grooming. During observations of March 2012, a colony of *O. cuniculus* of the grey morph, a kit of the much lighter yellow morph, appeared in the field with the other rabbits. It is very probable that all rabbits observed co-habit the same burrow. The rabbits observed in June 2014 were mature adults. The observations mentioned were made in two very distinct locations in Malta. Sometimes, Maltese hunters, especially with regards to coloration, say (vernacular speech), "*dik il-bejta taghmel sofor/homor*" which literally translates to: "*that nest produces yellow/red rabbits*".

The prime factor which could be responsible for the light colour adaptation is predation, and the deriving need for concealment.

Oryctolagus cuniculus has a very important role in the ecosystem, as it is one of the main prey animals. Predatorial pressure in the Maltese islands comes from the Least Weasel *Mustela nivalis* (Linnaeus, 1766), Cat Snake *Telescopus fallax fallax* (Fleischmann, 1831), Leopard Snake *Elaphe situla*

PART OF BODY	COLOURATION
DORSUM	REDDISH-GREY GRIZZLED WITH BLACK
FLANKS	PALE REDDISH GREY TO GREY
NAPE	RUSTY RED
VENTRUM - THROAT TO TAIL	PALE GREY TO WHITE
HEAD	PALE REDDISH GREY WITH PALE/WHITE EYE CIRCLES AND REDDISH NOSE
UPPER PART OF TAIL	BLACK
EAR TIP	DARK

Table 1. Overall Coloration in the grey morph of *Oryctolagus cuniculus*.

PART OF BODY	COLOURATION
DORSUM	SANDY
FLANKS	FAWN
NAPE	DARK SANDY
VENTRUM - THROAT TO TAIL	PALE GREY TO WHITE
HEAD	SANDY WITH FAWN MARKINGS WITH PALE/WHITE EYE CIRCLES AND DARK SANDY NOSE
UPPER PART OF TAIL	FAWN
EAR TIP	WHITE

Table 2. Overall Coloration in the yellow morph of *Oryctolagus cuniculus*.

Figure 1. Grey agouti morph of *Oryctolagus cuniculus*.

Figure 2. Yellow agouti morph of *Oryctolagus cuniculus*.

leopardina (Linnaeus, 1758), Black Whip Snake *Coluber viridiflavus carbonarius* (Lacépède, 1789), Algerian Whip Snake *Coluber florulentus algirus* (Jan, 1863) as well as the Black Rat *Rattus rattus* (Linnaeus, 1758) and the Brown Rat *Rattus norvegicus* (Berkenhout, 1769).

Populations of feral cats and dogs, as we observed, may also have an impact on the Maltese population of *O. cuniculus*, and human activity should also be taken too into consideration (Baldacchino et al., 1990), especially for hunting with nets, ferrets and dogs. In his book about the traditional Maltese rabbit dish, il-Fenkata, Cassar (1994) makes a reference to a report given by Mgr. Visconti's secretary (1582) on the fertility of Gozo, who states that the land is "*fertile abbondante e copiosa, non solo delle cose necessarie al vitto, ma di molte delizie ancora, perche abbonda di conigli, di lepri, di uccelli e di miele*".

French Angas (1842) recounts how maltese rabbits offered sport to the Governor and his officers. Also Luke (1963), quotes a seventeenth century Frenchman who appreciatively notes that rabbits and other game caught in Malta is fatter than their counterparts in Europe.

The previously quoted Leith Adams (1870) notes that; "*although there is every facility for rabbits to increase, especially among the rocky parts along the southern coasts, they are not plentiful, perhaps for the reason that they have formidable enemies in man and the weasel*".

All this reiterates why predation can be considered as one of the factors, if not the only, for the paler morph to emerge and thrive as a concealment technique (adaptive crypsis)

Stoner et al. (2003) confirmed that there is a correlation between lagomorphs living in open habitats, such as deserts and barren lands, and pale body coloration. Evidence also suggested that there is an association between red and grey coloration with rocky habitats.

Adaptation of colour morphs and variation of coat colour on the basis of habitat coloration was observed in different species, see, for example, Majerus & Mundy (2003) for the adaptive coloration in *Chaetodipus intermedius* (Merriam, 1889) from Valley of Fire, New Mexico, and also cited references (Cott, 1940; Foster, 1964; Lockley, 1980; Jaksic & Scoriguer, 1981; Monnerot et al., 1994; Caro, 2005; Millien, 2006; Van der Geer et al., 2010).

Perhaps the small size of the Maltese islands and the lack of habitat boundaries prevented total adaptation from occurring. On the other hand, this interbreeding amongst colonies could possibly be an advantage, as it keeps the rabbit always ready for change and adaptation, if need arises. Or perhaps, the selective pressure is not enough to totally phase out the disadvantaged coloured rabbits.

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